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PROF. DR. PÁL LIPTÁK ZUM 75. GEBURTSTAG

Es gehört wohl mit zu den besten menschlichen Tugenden, einen Rückblick in die Vergangenheit zu tun und sich an lange zurückliegende Ereignisse oder an den Lebensweg grosser Persönlichkeiten zu erinnern. Das ist auch das Anliegen dieses Beitrages, nämlich aus Anlass des 75. Geburstages eines Universitätsprofessors. Für die ungarischen Anthropologen ist das Jahr 1989 dazu angetan, um an den 75. Geburtstag von Prof. PÁL LIPTÁK zu erinnern.

PÁL LIPTÁK wurde am 14. Februar 1914 in Békéscsaba geboren. Nach einem ausgezeichneten Abitur setze er sein Studium an der philologischen Fakultät der Péter-Pázmány-Universität Budapest in den Jahren 1932—1937 fort. Mit Hilfe eines Sonderstipendiums (im Kollegium-Eötvös) wurde er schliesslich 1937 Gymnasiallehrer für die Fachter Naturkunde und Geographie. Seine Doktor-Dissertation verteidigte er im Jahre 1938 mit dem Ergebnis "summa cum laude". In den Jahren 1938—1949 arbeitete er als Lehrer in einem Lehrerbildungsseminar und an einem Gymnasium. Seine so erfolgreich begonnene Laufbahn wurde durch den Militärdienst und den Krieg, sowie durch die Kriegsgefangenschaft unterbrochen.

Am 1. Juni 1949 begann er erneut mit seiner Tätigkeit als Mitarbeiter der Anthropologischen Abteilung des Museums für Naturkunde in Budapest, wo er bis zum September 1955 als Museologe tätig war. Danach folgte eine Periode als selbständiger Wissenschaftler.

Obwohl er seine Doktor-Dissertation über Fragen der Siedlungsgeographie geschrieben hatte, wandte sich nun sein Interesse der Anthropologie zu. Hierbei

spielte sicherlich eine Rolle, dass er in den Jahren des Neubeginns gerade in diesem Fachgebiet eine neune Arbeitsmöglichkeit gefunden hatte, und natürlich auch die Tatsache, dass er schon in seinen Universitätsjahren 1932—1934 regelmässig anthropologische Vorlesungen bei Prof. LAJOS BARTUCZ belegt hatte. PÁL LIPTÁK intensive Forschungstätigkeit begann 1949 und sein besonderes Interesse wandte sich der historischen Anthropologie von Populationen zu, die vom 5. bis zum 13. Jahrhundert gelebt hatten. Besondere Bedeutung gewannen dabei seine Untersuchungen zur Herkunft des ungarischen Volkes. In seine Arbeiten flossen Dank seiner exzellenten Kenntnis der russischen Sprache auch die Ergebnisse der sowjetischen Anthropologie ein.

Ausdruck für die Intensität seiner Forschungen war die Verteidigung seiner "Kandidaten"-Dissertation am 30. Marz 1956 mit dem Thema: "Die wichtigsten Fragen der Anthropologie des 7. bis 13. Jahrhunderts im Donau-Theiss-Zwischenstromgebiet". Seit dieser Zeit beschäftigte er sich sehr intensiv mit Fragen der Differentialdiagnose europider und mongolider Grossrassen.

Ein Wendepunkt in seinen Leben war die Berufung als Dozent und Leiter am 16. Marz 1960 an den Lehrstuhl für Anthropologie der Attila-József-Universität Szeged. Obwohl wir auch in den vorangegangenen Jahren enge wissenschaftliche Kontakte gehabt hatten, so begann nun doch eine fruchtbare, zwanzig Jahre dauernde erfolgreiche Zusammenarbeit mit PÁL LIPTÁK. Der Anthropologische Lehrstuhl der Universität Szeged befand sich nach dem Wechsel von Prof. LAJOS BARTUCZ nach Budapest in einer schwierigen Lage. Es gab nur noch einen einzigen wissenschaftlichen Assistenten und zwei ältere Hilfskräfte. Der Neubeginn war für den eben eintreffenden neuen Chef schwierig, sehr viele Arbeiten mussten erledigt werden und oftmals gingen die Organisationsarbeiten und die Schreibarbeiten bis weit in die Nachtstunden. Letztendlich aber war das Ergebnis all dieser Bemühungen über den Zeitraum von 20 Jahren ein Lehrstuhl mit acht Mitarbeitern.

Eine der wichtigsten Aufgaben war die Lehre. Eine grosse Hilfe war es, als der Lehrstuhlleiter 1962 ein Lehrbrief für die Studenten herausgab, der später von PÁL LIPTÁK zum ersten in ungarischer Sprache geschriebenen Anthropologie-Lehrbuch weiterentwickelt wurde und das seit seinem ersten Erscheinen im Jahre 1969 mehrmals nachgedruckt wurde, und das auch gegenwärtig noch das gültige Lehrbuch dieses Faches für unsere Studenten ist. Eine grosse Hilfe war es ferner für Diplomanden und Doktoranden, als 1972 das zweibändige "Anthropologische Praktikum" erschien, zu dessen Erstellung er seine Mitarbeiter herangezogen hatte. In der Amtsperiode von PÁL LIPTÁK wurde der Lehrstoff der Anthropologie zwar auf insgesamt 3 Semester-Wochenstunden reduziert, was dem Fach jedoch keinen Abbruch tat. Schüler schreiben in der Vergangenheit 75 Diplomarbeiten und 17 Doktor-Dissertationen. Unter den Promovierten sind mehrere, die auch gegenwärtig noch als Anthropologen tätig sind, so z. B. ANTONIA MARCSIK, KÁROLY VÁMOS und MÁRTA FERENCZ.

Trotz der bescheidenen personellen Verhältnisse und dem grossen Aufgabenbereich in der Lehre, war das Hauptaugenmerk auf die Forschung gerichtet. Es mag fast unglaublich erscheinen, aber die Mitarbeiter des Lehrstuhls

veröffentlichten in den zurückliegenden 20 Jahren insgesamt 210 grössere oder kleinere Publikationen. Der Schwerpunt der Forschungen war entsprechend der Interessen PÁL LIPTÁKs unter Ausnutzung der anthropologischen Sammlung des Lehrstuhls sowie von Ausgrabungsfunden vorwiegend auf die historische Anthropologie ausgerichtet. Die wissenschaftliche Tätigkeit und die Sammlung des Lehrstuhls hatte auf zahlreiche ausländische Spezialisten eine grosse Anziehungskraft und sie begannen, sich für unser Lehrstuhl zu interessieren. Von diesen Wissenschaftlern seinen hier folgende Namen erwähnt: DEBEZ, CSEBOKSZAROV, GINZBURG, TROFIMOVA, BACH, GRIMM, STLOUKAL, BOEV, CORRENTI, OLIVIER, die in Fachkreisen wohl bekannt sind. Die Verbindungen des Lehrstuhls wurden erweitert. In den 20 Jahren bereisten die drei Lehrkräfte des Lehrstuhls 14 Länder und bei 55 Ausreisen wurden insgesamt 30 Vorträge gehalten. Der Lehrstuhl pflegt mit 35 Forschungseinrichtungen einen regen Schriftenaustausch. Behilflich war hierbei vor allem die von Prof. PÁL LIPTÁK herausgegebene "Acta Biologica Szegediensis", in der regelmässig anthropologische Beiträge erschienen. Die historische Anthropologie gewann weiter an Bedeutung, als am 15. Januar 1969 der Direktor des Lehrstuhls seine Habilitations-Schrift mit dem Titel: "Paläo-Anthropologie und Ethnogenese der Ungarn" erfolgreich verteidigte und am 1. Juli 1969 zum ordentlichen Hochschulprofessor berufen wurde.

Die Forschungen auf dem Gebiet der historischen Anthropologie wurden weiter intensiviert und auf die gegenwärtig lebende der Ungarn ausgedehnt. Die Ergebnisse dieser Arbeit fanden Eingang in Beiträge zu fünf Monographien. Unter Beteiligung anderer wissenschaftlicher Einrichtungen untersuchten die Mitarbeiter des Lehrstuhls ferner die körperliche Entwicklung von Kindern und Jugendlichen. Parallel dazu liefen die historisch-anthropologischen Untersuchungen natürlich weiter.

Die Mitarbeiter des Lehrstuhls beteiligten sich nicht nur am wissenschaftlichen Leben der Universität, sondern waren auch gesellschaftlich sehr rege. So arbeiteten sie im Anthropologischen Fachsektion der Ungarischen Biologischen Gesellschaft und in der Anthropologischen Kommission der Ungarischen Akademie der Wissenschaften mit und waren darüber hinaus in verschiedene Körperschaften der Universitäten integriert. Dies macht deutlich, dass der Leiter des Lehrstuhls seinen Mitarbeitern bei der Wahl ihres Forschungsbereiches weitgehend freie Hand liess und das Profil des Hauses nicht auf eine bestimmte Richtung beschränkte. Den am Lehrsuhl tätigen Wissensachaftlern kam diese Haltung PÁL LIPTÁKs letztendlich in ihrer Lehr- und Forschungstätigkeit weitgehend entgegend.

In dem Jahren von 1960 bis 1980 wurde die Zusammenarbeit mit den Achäologen der Museen von Szeged, Baja, Hódmezővásárhely, Szentes, Debrecen, Kecskemét und Békéscsaba weiterentwickelt und ausgebaut. Diese Zusammenarbeit gestattete uns in erster Linie die Erweiterung der historisch-anthropologischen Sammlung. Ferner wurde die bis heute bestehende enge Zusammenarbeit mit der Zahn- und Kieferorthopädischen Klinik der Albert-Szent-Györgyi-Universität für Medizin, Szeged, sowie mit dem Institut für Forensische

Medizin der gleichen Einrichtung aufgenommen. Enge wissenschaftliche Zusammenarbeit erfolgte auch mit den Anthropologen, die am Zoologischen Institut der György-Bessenyei-Hochschule für Pädagogik in Nyíregyháza tätig waren.

Die wissenschaftliche Arbeit Prof. PÁL LIPTÁKs fand ihren Niederschlag in 137 Publikationen. Davon waren 94 der historischen Anthropologie gewidmet, 7 der ethnischen Anthropologie und 33 der Geschichte der Wissenschaften, popularwissenschaftlich oder anderer Art fachlich ausgerichtet. Ferner waren es seine Lehrbriefe und das Lehrbruch, sowie einige Beiträge zu Monographien. 1983 erschien seine Habilitationsarbeit in englischer Sprache. Prof. PÁL LIPTÁK gehörte nicht zu den "Reisewissenschaftlern", dennoch hielt er viele Vorträge über anthropotaxonomische Fragen und seine wissenschaftlichen Ergebnisse trug er in Vorträgen auf mehreren ausländischen Kongressen und Studienreisen vor. So u. a. 1960 in Paris, 1973 in Chicago, 1976 auf dem Internationalen Kongress der Anthropologen und Ethnographen in Beograd auf dem 2. Internationalen Finnisch-Ungarisch-Kongress 1965 in Helsinki, sowie anlässlich einer Studienreise 1970 nach England.

Für seine verdienstvolle Arbeit wurde PÁL LIPTÁK mehrmals ausgezeichnet, so z. B. am 4. April 1960 für seine Leistungen auf dem Gebiet der Museologie mit der Medaille für "Sozialistische Kultur" und 1980 für seine Verdienste in der Lehre mit der Medaille für "Ausgezeichnete Arbeit". Der Wissenschaftliche Rat der Attila-József-Universität Szeged verlieh 1989 erstmalig die von der Universität gestiftete "LAJOS-BARTUCZ-Erinnerungsplakette" an Prof. PÁL LIPTÁK, der diese hohe Auszeichnung aus den Handen des Rektors in Anerkennung für seine Leistungen am Aufbau und der Entwicklung des Anthropologischen Lehrstuhls empfing. Diese Plakette können nur solche ungarischen oder ausländischen Wissenschaftler erhalten, die sich durch überdurchschnittlich beachtenswerte Leistungen in Lehre und Forschung, sowie um die Weiterentwicklung des Anthropologischen Lehrstuhls in Szeged verdient gemacht haben und die die Zusammenarbeit mit ausländischen Institutionen erweiterten.

Prof. PÁL LIPTÁK beendete seine zwanzigjährige Leitungstätigkeit des Lehrstuhls am 30. Juni 1980. Die Verabschiedung von seinen engsten Mitarbeitern, Kollegen und Schülern erfolgte auf einer wissenschaftlichen Sitzung am 11. Dezember 1980. Die Naturwissenschaftlichte Fakultät verabschiedete den scheidenden Kollegen auf einer ausserordentlichen Sitzung am 12. Dezember.

Mit diesem kurzen Rückblich auf das Lebenswerk von Prof. LIPTÁK möchten die ehemaligen Mitarbeiter dem Jubilar ganz herzlich zu seinem Ehrentag gratulieren und ihm vor allem Gesundheit und Schaffenskraft wünschen.

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DR. GY. L. FARKAS

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PROF. DR. AMBRUS ÁBRAHÁM
(1893—1989)

I took leave of him as his former student and colleague at his dying bed. Only his eyes were talking, gazing quietly to a great distance. Perhaps, this was the last time, they were seeking the secret of life. Then we sadly read:

THE HUNGARIAN ACADEMY OF SCIENCES, THE JÓZSEF ATTILA UNIVERSITY SZEGED let you know with deep sorrow, that

AMBRUS ÁBRAHÁM

the member of the Hungarian Academy of Sciences, emeritus professor of the József Attila University Szeged, honorary president of the Hungarian Biological Society, outer member of Royal Society (London), member of the Indian Academy of Zoology (Agra), member of Szeged Academic Board, member of the Scientific Educational Society, member of the Editorial Board of Zeitschrift für mikroskopisch-anatomische Forschung, honorary doctor of the József Attila University, winner of the golden order of Labour, the KOSSUTH-prize and the flag order of the People's Republic Hungary died in loth of January 1989 in the 96th year of his life.

We lost in his personality a scientist with exceptional knowledge and international fame, an outstanding representative of comparative zoology, neurohistology, and neuromorphology.

I see his vivid face just like many many times before, just like I keep it in my mind together with many others. We begin to remember him with this picture writing down what an outstanding personality he was.

He was born in 20th of November, 1893 in Tusnád, Csik county, Transsylvania. He was the 7th child of a well-to-do peasant family with 10 children. His birthplace is situated at the foot of the mountain Hargita; a valley with stream-cut meadows, grasslands, plough-lands. It is surrounded from three sides by Tusnád stream. The forest with wolves and bears is very near. "The beautiful forest is the spot of dreams, desires, unimaginable joys and painful memories." Memories which followed him when he was meditating here in Szeged beyond the river Tisza, at the Maros riverside; he was listening the message of Transsylvanian land. He lead a Transsylvanian way of living, especially in his work. In his home he was writing, preparing for lectures until dawn. The nights were very short, the days full of very hard work. Just like in the family home, where the adolescent child made hay in a competition with his father. He used to work from early morning till late in the evening. He was trained in this way by his birthplace and plenty of work.

When he was eleven, he attended the secondary schools in Csiksomlyó and Csikszereda. During this time he was fond of collecting and classification of insects.

After his eminent GCE he had to decide in the choice of profession. He had the idea of financial and intellectual independence from home, to find the way to the science, and he tried to answer the questions of "from where?", "why?" and "where?". These last questions were his strongest motivations. In 1913 he applies for admission in the Premontre order, in Jászó. This decision brought him more

doubts than satisfaction. So, besides theology he turned to biology and he became the student of PÁZMÁNY PÉTER University Budapest. His subjects were natural history and geography.

He spent most of his time in the Institut of General Zoology and Comparative Anatomy and Histology. He prepared his competition essay on the reproduction of Infusoria living in *Amphibia* in this institut. His capability, exact, enthusiastic work, was recognized by the director of the institut, LAJOS MÉHELY, who appointed him to assistant lecturer in 1917. He was then graduated as secondary school teacher of biology and geography in 1919. At the same time, because of conscience, he finished his theological studies too. This period was very difficult. But the poor lodging, starving, the suffer from cold could not brake his enthusiasm for his work. He teaches zoology at the Teacher's Training College of English Ladies, at the same time he gives lectures in both of the divided Department of Zoology. He is the leader of histological practicum too. This latter was the greatest experience for him. He became a genuine comparative histologist here, learning and teaching at the same time.

MÉHELY was not very well experienced in neurohistology, so he was not able to ensure support to the young scientist. In spite of this, he played a crucial role in his career. He called his attention to the thigh-glands of lizards. Then he finished his doctoral thesis titled: "Comparative anatomical, histological and physiological studies on thigh-glands of *Archaeo-* and *Neolacerta* species". MÉHELY called his attention to the innervation of lizard penis on the basis of phylogenetic considerations. From this work he wrote his thesis: "The innervation of the lizard skin". He was the first who found intraepithelial and corial nerve endings in the genital organs. The results were determining for his further research work. In 1926 he wrote his professorial thesis titled "The histology of vertebrate animals", then he gave his entrance lecture titled "Nerve endings".

He was the candidate for the place of head of department after the death of Méhely. It is incomprehensible even now, that he was not appointed. On the 1st of August 1934 he leaves Budapest and the PÁZMÁNY PÉTER University. He became the head of Department of Zoology at the Teachers'Training College. At that time Szeged was the second largest town of the country. The town accepted him and he also was fond of the town. The neglected department was recreated with very busy scientific life. The students were selected from the most capable and devoted secondary school pupils. They were listening the lectures of high university level with enthusiasm, and some of them joined to the research group too.

In 1938 he was the research fellow of Neapolitan Zoological Station. He worked at the same Hungarian desk where the famous Hungarian biologist, neurohistologist ISTVÁN APÁTHY earlier. In the 1st of September 1939 he was promoted to the leader of the Teachers' Training College. After he had made prosper a department, he could do it with the whole college.

In 20th of November — as it was expected — he was promoted to the director of the Department of General Zoology and Biology, where among his ancestors were the outstanding ISTVÁN APÁTHY and JÓZSEF GELEI. He was a successor

worthy of his ancestors. The department soon became a unique establishment rich in modern equipment, and modern scientific attitude. The nicely arranged collection of animals with the famous bird collection of PETER BERETZK occupied the main hall on the ground floor. This unique collection unfortunately was lost later. Each biological subject except botany was taught in this department and this meant a lot of work. At the same time an important multilateral research work was done here too. It is not accidently that the windows of the department were lighting till late in the night. The windows of professor ÁBRAHÁM's laboratory were light too. Perhaps the greatest and most valuable neurohistological collection of 19.500 sections and preparates were made by his colleagues, MÁRIA CSOKNYA, LAJOS ERDÉLYI, MÁRIA FISCHER, IMRE HORVÁTH, EMIL MINKER, and especially with the help of ARANKA STAMMER. Each preparate is a historical example of the devoted care, demand, the ideas of the creators. These preparates tell us about the methods, aims, motives, of his research work which embraced almost the whole animal world and in some respect the human organism as well. His research dealt with almost all problems of light microscopic study of nervous system, the questions of morphology and function, the phylogeny, and often pathological aspects too.

He considered that the good methods are crucial in the research, so he made experiments to improve, or find out new procedures, especially during the first period of his career. For example, he applied his own method and the methilene-blue staining of Ehrlich for the identification of exteroreceptors of *Amphipods* and *Amphibia*. He used the silver impregnation methods of RAMON Y CAJAL, GOLGI, BIELSCHOWSKY, BIELSCHOWSKY-GROS, the gold- toning methods of BIELSCHOWSKY, CAJAL-LENHOSSÉK, STÖHR and JABONERO. In 1926 he preferred the STÖHR-method, but later he discovered the advantages of BIELSCHOWSKY and BIELSCHOWSKY-GROS methods. The majority of his preparates was made with silver impregnation by BIELSCHOWSKY-ÁBRAHÁM. The sections made in this way are very beautiful, clear, free of disturbing factors.

He very rarely made photographs of his preparates. He was for the drawings. So he could follow the course of nerve fibres, their spatial arrangements, connections. He was right. His drawings were always authentic.

He was a devoted neuroscientist throughout his life. It is difficult to emphasize any of his results. Perhaps the research of receptors could be emphasized. He started his research career with this and reached new and newer results. In this field he is among the best scientist of the world. Two scientific books were published in this field by the Publishing House of the Hungarian Academy of Sciences: "The Histological Atlas of Receptors" (1972), and "Iconography of sensory Nerve Endings" (1981).

He devoted a considerable part of his life to the research of the innervation of cardiovascular system. He published fascinating pictures of the connections of nerve endings and smooth muscles, the sensory receptors of reflexes important in the regulation of blood pressure, about the baroreceptors (pressoreceptors), about the chemoreceptors sensitive for the chemical composition of blood, about nerve plexuses found in the heart wall of various animal groups, dendritic trees,

neurofibrillar endplates, loose, mainly encapsuled sensory nerve endings. The characteristic forms of sensory nerve endings appear in mammals without transition according to his studies. He draw phylogenetic conclusions from this fact. He published his results on the cardiovascular system in a monography in English, titled "The microscopic innervation of the heart and blood vessels in Vertebrates including man" (in a joint edition of the Hungarian Academy of Sciences and the Pergamon Press Oxford, 1968). In 1971—1972 he represented the results of his investigations on the heart of the *Mammalia* and the sensory innervation of blood vessels in 22 partly coloured tables of the "Atlas of cardiovascular pathology" which is in course of publications at Montreal.

His other remarkable research field was the comparative study of the innervation of the gastrointestinal tract, the neural connections in the enteric ganglia and in the smooth muscular layer of various invertebrate and vertebrate species. He described in detalis those similarities and differences which were detectable at the different synapses of various *Insects* and *Mollusca* and *Vertebrates*. On the basis of the experiments made on molluscs and on leech *(Hirudo medicinalis)* together with EMIL MINKER, he took the part of Neuron Thesis, which was his idea together with other famous scientists like RAMON Y CAJAL, MIHÁLY LENHOSSÉK and other. According to this the nerve fibres, neurofibrils do not go through the cells, centers, muscle fibres, they are not in continuity as it was announced by his prominent ancestor ISTVÁN APÁTHY, and other famous contemporaries. He recognized without doubts the essence and importance of contiguity in the neural transmission, which was supported not only with anatomical but functional, pathological and phylogenetic evidences as well. He was right. This is not in contradiction with the words written by him: "The nerve fibres of the smooth muscle have no visible end or if they have that it is something (terminal reticulum) that cannot be named a terminal at all." He established that the synaptic connections of vegetative nerve endings are extremely rare.

His works on the eye are also noteworthy. He described first the innervation of ocular muscles. It is a pity that he could not perform experiments on more animal species and so he could not publish a greater comparative study.

He was interested not only in the peripheral nervous system, the importance of ganglia, their structure. He tried to deal with the central nervous system as well. He described large, round neurosecretory cells from the prosencephalon of *Dytiscus marginalis*, which are very similar to the neurosecretory cells of nucleus paraventricularis and nucleus supraopticus of *Vertebrates*. He accomplished the study of innervation of heart and aorta with the localization of acetylcholinesterase. He was very interested in the presence, origin, migration of vesicles their role in the transfer: He sadly noted that the thousands of preparates could not give an answer to these questions. They were not able to give an answer. Classical neurohistologist asked the questions.

He was fascinated by the results of electron microscopic neuroanatomy. He also begins new research in this field at the age of 72. Until his death he published 38 articles in this field. He goes on the same way which was well-known at light

microscopic level for him. He did not loose his way in the submicroscopic world either. He proved again his words:"I write about things what I have seen, I write as I have seen ... creating hypotheses, making axiomas, collecting theories, that is not my way!".

The irresistible instinct desire of childhood is chasing him to the free nature, especially to the mountains. They made excursions with his colleagues to the mountains Pilis, Mátra, Bükk, to the fresh springs and streams. The results of these excursions are his hydrobiological publications, which are closely related to his life-work. Besides research teaching job was his other favourite work. Thousands can remember his exciting, logic, excellent lectures, and thousands can use the knowledge got in this way in various departments, laboratories. A great number of textbooks, handbooks, rewievs of general or scientific interest contain his knowledge, his ideas connected with deep theoretical or with the practical life.

He was a globe-trotter. He did not want to learn abroad, but to teach there too. To reveal those secrets, which were known by him through his preparates. He thought everything can be found in the books and scientific articles. He loved truth, he found and formulated his own truth. He was acknowledged both at home and abroad. He was member of famous societies, he won a lot of prizes. In 1945 he is the correspondent member of Hungarian Academy of Sciences. In 1953 he won the KOSSUTH prize for his research work made on the basis of Pavlovian theories. In 1955 he was chosen to outer member of Academy of Zoology Agra (India), in 1958 the Royal Society of Medicine (London). In 1960 he became the ordinary member of Hungarian Academy of Sciences. Ordinary and honorary Chairman of the Hungarian Biological Society, which was organized by him. Besides the golden order of labour he won the flag order of the People's Republic Hungary, which is a prize for the most outstanding personalities.

He went on pension in the 1st of August 1967, at the age of 74. He cited meditating the great truth: "which rises, goes down, who was born, is getting older." Yet, the pension is a painful fact for him, since he feel himself strong and active. He keeps working, but he misses the teaching job very much. He hardly notices the passing of time. He is walking with straigth back along the riverside of Tisza, not realizing that his heart beat is slowing down. Then the spring is exhausted, and he exists only in his works and in our memories. We realize, that the last distinguished great representative of Hungarian classical neurohistology was beried in the Farkasréti cemetery.

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Akad. Ért.	=	Akadémiai Értesítő, Budapest (Hung.)
Alf. Tud. Int. Évk.	=	Alföldi Tudományos Intézet Évkönyve, Szeged (Hung.)
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Orv. Gyógysz. Lapja	= Orvosok és gyógyszerészek lapja, Budapest (Hung.)
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ACTA BIOL. SZEGED. 35. PP. 37—38 (1989)

PÁL GREGUSS LIFE AND ACTIVITY
(In memoriam Professor Greguss)

PÁL GREGUSS was born on the 31 st of December, in 1889 in Tornya, Arad county. He aitended grammal school in Arad, then graduated in Budapest as a secondary school teacher of biology and chemistry. During the first World War he was a soldier working at the Prague University. After coming home he taught at Teacher's Training Colleges first in Csáktornya then in Budapest. In 1919 he obtained a PH degree in Budapest. Starting from 1920 he worked as an assistant lecturer with professor HOLLENDONNER. In 1927 he was appointed honorary lecturer at Péter Pázmány University. In the same year he was entrusted with the organizing and managing of the Institute of Botany at the Debrecen University. A year laer he was a professor of the Teacher's Training College in Szeged. When professor ISTVÁN GYÖRFFY left the Szeged University in 1940, he was appointed professor of the Department of Botany of Szeged University. A large scale teaching and research work was directed by him here for more than 25 years. He did not stop his researches even after his retirement (1965). He was one of the most prolific Hungarian botanists having the greatest number of publications.

His first paper was published when 20, in 1909. Summing up his fruitful and diligent research work we can find 46 books, 10 university textbooks and 254 scientific publications by his pen. His life is an excellent example of a scientist who after retirement wants to work and can produce wonderful results. During the years of his retirement he wrote 55 papers and after his 90th year, he added 6 more ones. Two days before his death, at the age of 94 he still went to the Department of Botany where in his small study he was full of plans.

He did researches almost in every field of Botany. From the 30-ies on he started to deal with tree anatomy and with the research of died out plants (fossils). His monography (Lomblevelű fák meghatározása, Közép-Európai lombos fák és cserjék meghatározása szövettani alapon) "Xylotomical determination of deciduous trees and shrubs in Middle Europe" was published in 1947 and made him a name among the botanists. Then he became interested in the Examination of gymnospermous tree trunk and in 1955 he finished his brilliant work (Xylotomische Bestimmung der heute lebenden Gymnospermen) "Xylotomical determinations of the present gymnospermous trees", containing the structure of xylem of 360 gymnospermous species and this work has become well known all over the world. In the international scientific life PROFESSOR PÁL GREGUSS has become famous first of all as a xylem anatomist on the ground of his numerous books and studies. If there were a championship in science like in sports, professor GREGUSS would be on the top of a world table as an anatomist. He spent about four decades at colleges and universities and heleped to train not only teachers of biology but a number of researches as well who play a very important role in our present scientific life. The thought of evolution was the guiding principle in his lectures. He was suggestive and clear to describe the flora different geological ages. Delivering lectures he never failed to implant the love of nature, life and people in his students. He defined three

treasures in our life: love, health and knowledge. Beside his teaching and scientific work he took part in public affairs, too. After 1956 he was the Rector of our university. It would be difficult to enumerate the medals he was awarded as an appreciation of his work. After the Kossuth Prize and Orders of Labour, he was awarded with the Flag Decorated Orden of the Hungarian People's Respublic. Professor GREGUSS now would be a 100, and this is the reason why we are organizing the 5th of Symposium Hungarian Plant Anatomy.

Now I wish the participiants of the symposium to achieve similar results as professor GREGUSS did in plant anatomy and work as long as he did.

S. GULYÁS

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THE VEGETATION MAP OF THE TRIPOLISZ UNESCO BIOSPHERE RESERVE CORE AREA, KISKUNSÁG NATIONAL PARK, HUNGARY

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Abstract

The paper presents the vegetation map, on a scale of 1:5000, of the Tripolisz UNESCO biosphere reserve core area and a short description of the main vegetation units. A detailed analysis of the nature conservation problems of the core area is also given.

The dominant associations on the higher reliefs of the territory are *Astragalo-Festucetum rupicolae, Achilleo-Festucetum pseudovinae* and *Potentillo-Festucetum pseudovinae*. The majority of the deepest reliefs is covered by stands of *Agrostio-Caricetum distantis, Astero-Agrostetum stoloniferae, Agrostio-Alopecuretum pratensis, Caricetum melanostachyae* and *Caricetum acutiformis-ripariae* associations. Most of the core area is covered by halophilic plant communities adapted to the different haloecological conditions; the most characteristic associations are *Artemisio-Festucetum pseudovinae, Lepidio-Puccinellietum limosae* and *Lepidio-Camphorosmetum annuae* on saline and sodic soils. The cenological characterization of these associations is reported at a depth necessary for the interpretation of the units on the vegetation map.

Key words: biosphere reserve, environmental conservation, halophilic vegetation, vegetation mapping, water management.

Introduction

The Tripolisz UNESCO biosphere reserve core area is situated in territory II of the Kiskunság National Park (Fig. 1). It has been demarcated in the northernmost part of the National Park. Its area is close to 1 km^2 (TÓTH, 1984; cf. BATISSE, 1982).

In addition to natural processes, the anthropogenic impacts have played an important role in the development of the present relief. The Tripolisz core area belongs in the flood-plain of the River Danube, and therefore the most sweeping changes were caused by the inundations of the river; the loess deposit from the glacial period has not come down to us in its original form. Downwards from a soil horizon depth of 0.5—1.5 m, a river-gravel layer can be found. The operation of the surrounding gravel-pits points to the existence of a very thick gravel layer under the surface. Alluvium of varying width and primary particle composition has been deposited from the receding water onto the gravel layer (MOLNÁR, 1961; 1970; 1977). Prior to the highest dikings, the high water-table meant that the lower parts of the core area were inundated for most of the year. The water-table came so close to the surface that the ground-water occasionally gushed out at time of the Danube's average water-level. A connection between the river and the low flood-plain was ensured by the predominance of the sand and gravel layers (PÉCSI, 1959). The high

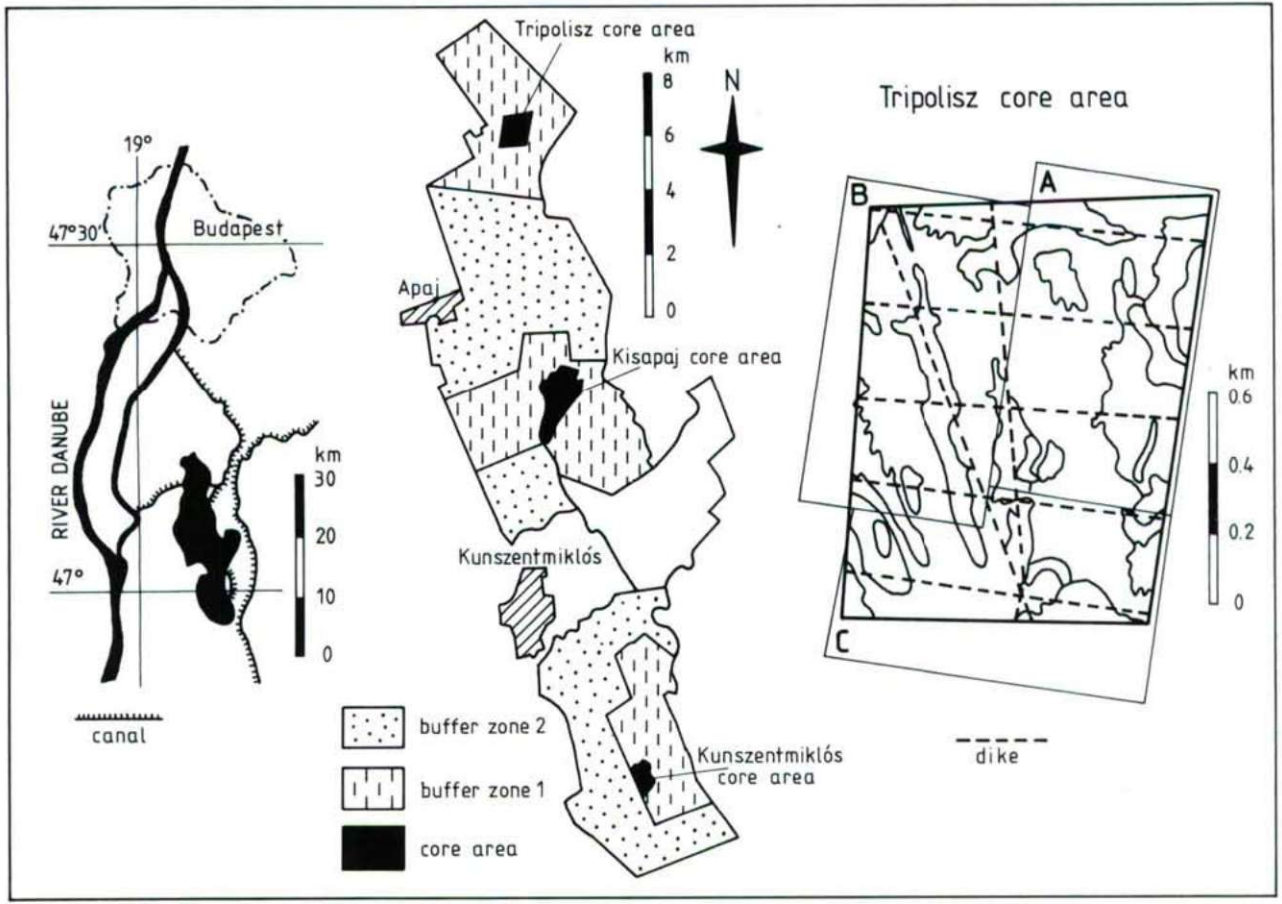

Fig. 1. Geographical location of territory II of the Kiskunság National Park and the Tripolisz biosphere reserve core area. The third sketch-map shows the connection of the three map sheets (A, B, C).

water-table affected the soils of the higher reliefs in another manner: the high concentration of water-soluble sodium salts in the ground-water and their accumulation in the surface layers of the soils caused the alkalization of the core area (VÁRALLYAY, 1965; VÁRALLYAY et al., 1984).

Prior to the dikings, *Lepidio-Puccinellietum* and *Lepidio-Camphorosmetum annuae* associations lived on sandy solonchak soils. Similar vegetation occured on the heavy alluvial soils of the lower reliefs (RAPAICS, 1927; MOESZ, 1940; SOÓ, 1947). On the heavy alluvial soils of the higher reliefs, the *Artemisio-Festucetum pseudovinae* association lived on solonetz soil. There were *Molinietum* grasslands on the evenly wet soils; this seems to be verified by the survival of *Betonica officinalis* in the territory. As a result of the sinking of the water-table (caused by the water management), the size of permanently water-covered areas decreased, and they finally disappeared; the solonchak soils become leached and turned into solonetz soils; the vegetation of the higher reliefs was transformed into the relevant more dryness-tolerant types (BAGI, 1987; 1988b).

The wind played an important role in the development of the present relief. The long depression in a NW-SE direction emerged due to the prevailing north-westerly wind. This seems to be verified by the emergence of a bay-bar form at the south-eastern end of this depression. Such a form of the relief should have developed if there was open water in the depression for a long time (cf. CAILLEUX, 1952).

The anthropogenic impacts had an important role in the shaping of the present landscape of the core area. In approximately a north-south direction, a 3—4 m wide canal (which has long lost its function) runs through the area; in addition to this wide canal, five small canals run through the area in approximately a west-east direction. Additionally, numerous dikes form a complicated network. Everything points to the earlier plan to introduce rice cultivation to this territory.

The difference in height between the highest and deepest reliefs in the core area is not more than 1.5 m.

Materials and methods

The vegetation map has been prepared on the basis of field surveying. The mapping was particularly facilitated by the dikes and canals; after the determination of their positions, the preparation of the map was greatly simplified. In spite of this, the exactness of this map is poorer compared with a map prepared on the basis of aerial photographs (BAGI, 1987; 1988a). However, the great number of fixed points permits the subsequent transfer of the results onto an aerial photograph.

The map is issued in the form of sheets joining without overlap. The three map sheets and their key are formally published as an appendix to this paper.

In the present paper, the description of vegetation units follows the system and nomenclature of the Zürich—Montpellier Phytosociology School (BRAUN-BLANQUET, 1951), despite the fact that the categorization of several transitional vegetation units (which have developed due to the intensive vegetational transformation processes) encountered difficulties. The denomination of the species and cenosystematic units accordings to the work of SOÓ (1973), completed with the cenological results of BODROGKÖZY (1958; 1960; 1970).

The map was elaborated in 1988.

Results

1. A SHORT CHARACTERIZATION OF THE VEGETATION UNITS

For the sake of a good arrangement, the system of cenotaxa of the vegetation map can be outlined as follows;

Cypero-Phragmitetea SOÓ 68
Phragmitetea TX. et PRSG. 42
Magnocaricetalia BR.-BL. 25
Caricion gracilis SOÓ 71
Caricetum acutiformis-ripariae SOÓ (27) 30
— *caricetosum acutiformis*
Caricetum melanostachyae
Puccinellio-Salicornea SOÓ 68
Festuco-Puccinellietea SOÓ 68
Festuco-Puccinellietalia SOÓ 68
Puccinellion peisonis WENDELBG. 43
Lepidio-Puccinellietum limosae (RAPCS. 27) SOÓ 57
Lepidio-Camphorosmetum annuae (RAPCS. 27) SOÓ 57
Junction gerardii WENDBG. 43
Astero-Agrostetum stoloniferae BODRK. 60
— *typicum (agrostetosum stoloniferae)*
— *asteretosum pannonici*
— *bolboschoenetosum maritimi*
Agrostio-Caricetum distantis (RAPCS. 27) SOÓ 30
— *typicum (agrostietosum stoloniferae)*
— *Carex distans* facies
Caricetum divisae SLAVNIC 48
Beckmannion eruciformis SOÓ 33
Agrostio-Alopecuretum pratensis SOÓ (33) 47
— *agropyretosum repentis*
Artemisio-Festucetalia pseudovinae SOÓ 68
Festucion pseudovinae SOÓ 33
Achilleo-Festucetum pseudovinae (MAGYAR 28) SOÓ (33) 45
Artemisio-Festucetum pseudovinae (RAPCS 16) SOÓ (33) 45
— *typicum*
—— *Artemisia santonicum* facies
—— *Hordeum geniculatum* facies
—— *Podospermum canum* facies
Festuco-Bromea BR.-BL. et TX. 43
Festuco-Brometea BR.-BL. et TX. 43
Festucetalia valesiacea BR.-BL. et TX. 43
Festucion rupicolae SOÓ (29) 64

Astragalo-Festucetum rupicolae (MAGYAR 33) SOÓ (56) 64
Potentillo-Festucetum pseudovinae (MAGYAR 28) SOÓ 50
Cynodonto-Festucetum pseudovinae SOÓ 57
Cynodonto-Poetum angustifoliae (RAPCS 26) SOÓ 57

The lowest parts of the core area are covered by *Caricetum acutiformis-ripariae* association. Its habitat in the depressions is often completely dried out for several years. Therefore, a dryness tolerant *caricetosum acutiformis* subassociation has now developed. If the lack of water continues, the stands of this community will disappear from the territory. Towards the higher reliefs, *Caricetum acutiformis-ripariae* is substituated by *Caricetum melanostachyae* community. The largest stands of this community can be found in a depression in the western part of the core area, but the community is also extensive in the north-western and south-western parts of the territory. The inundation still persists for most of the year and the high organic matter content in the surface layers of the soil saves their stands from salinization. *Bolboschoenus maritimus* or other species indicating increasing salinity do not occur in the stands of sedgy associations.

Along the wide canal, the stands of the *Astero-Agrostetum stoloniferae* association are largest in the depressions dug during the development of the canal crossing the core area in a roughly north-south direction. Depending on the depth of these depressions and dips, the subassociations of the *Astero-Agrostetum* community have developed, adapted to the different hydro- and haloecological conditions; these subassociations involve *bolboschoenetosum maritimi* in the deepest depressions, *asteretosum pannonici* in the intermediate ones, and *agrostetosum stoloniferae* in the higher depressions.

An important environmental protection problem results from the development of *Astero-Agrostetum* under such an anthropogenic effect; the *Caricetum* communities of the saline plains could not be restored by the scouring of the depressions and the simple sinking of their original habitats. After these interventions, not the anticipated *Caricetum* associations would develop, but *Bolboschoenetum maritimi* or (on the not so deep parts of the territory) the *Astero-Agrostetum* community. The protection of the *Caricetum* communities may be solved by delaying the organogenic sedimentation, i. e. the mowing and removal of the biomass.

The *Agrostio-Caricetum distantis* association grows on the less salt-affected soil. The high organic matter content and the less heavy soil are very important for the development of this vegetation type. This hydrophilous community occurs in small patches in the western part of the core area; a larger stand can be found in the north-eastern part of the core area. The survival of the typicum and *Carex distans* facies of this community depends on the stabilization of the water relations.

On similar reliefs, but with more heavy soil, an *Agropyron* repens and an *Agropyron intermedium* facies of the *Agrostio-Caricetum distantis* community have developed. It would be better to consider these stands as the *agropyretosum repentis* subassociation of the *Agrostio-Alopecuretum pratensis* community because the soil is close to a typical solonetz (BODROGKÖZY, 1970). These stands are almost

identical with those described in the Kisapaj core area. Those stands were in successional connection (towards the deeper reliefs) with the typical *Agrostio-Alopecuretum association* (BAGI, 1987). An especially high similarity is observed between the Kisapaj stands and a large eastern stand at Tripolisz. This vegetation type can be found in smaller or larger patches in all parts of the core area; it sometimes forms zones encircling the deeper parts. The territorial distribution of the *Agropyron* species is characteristic: *Agropyron repens* is more frequent in the eastern and central parts, while *Agropyron intermedium* forms large stands in the south-western part of the core area.

The stands of the *Lepidio-Puccinellietum limosae* community lie only on the western side of the wide canal. They grow in the greatest extents in the western part of the core area and outside its boundary. For the effective protection of these stands, movement of the boundary to the west would be reasonable. The *Lepidio-Puccinellietum* community is connected to the *Artemisio-Festucetum* community of higher reliefs with a berm 40—60 cm in height. In the contact zone, a *Lepidio-Camphorosmetum* association has developed along the berms. These alkaline berms have scenic significance; the protection of this unique landscape is a very important task.

In the central part of the core area, the stands of *Caricetum divisae* community can be found in the contact zone of *Lepido-Puccinellietum* and *Artemisio-Festucetum* communities. Consequently, some of the stands contains elements of *Junction gerardii,* while others contain *Festucion pseudovinae*. Typical stands of the association are circumscribed to a small area.

Towards the higher reliefs, the *Lepidio-Puccinellietum* association is substituted by *Artemisio-Festucetum pseudovinae* association. Where the two communities are not separated by berms, transitional stands have developed.

The majority of the mapped territory is covered by the *Artemisio-Festucetum pseudovinae* association. Especially large stands can be found in the eastern part of the core area. This part is of scenic significance, and therefore its protection is needed. The association is tolerant towards anthropogenic impacts and grazing. It is endangered only by a further decrease in the water-table. This is why one of the most important needs is the maintence of the water-table at the required level.

In the western part of the core area, a *Hordeum geniculatum* facies of the *Artemisio-Festucetum* association has developed on transitional solonchak-solonetz soil at the deeper parts of this community type. In the other parts of the core area, due to the more heavy soil, the typical *Artemisio-Festucetum* is connected to the other associations of deeper reliefs, with a *Podosperum canum* facies of the *Artemisio-Festucetum*. The stands of this facies form wide zones on the gently sloping territories. At the time of flowering, the typical stands of wormwood saline plain association are surrounded by the flowery fields of *Podosperum canum*.

The stands of *Artemisio-Festucetum* connected with the higher reliefs show strongly degradative characteristics indicative of the salt outwashing from the soil of the higher reliefs; there is a decrease in the coverage of *Festuca pseudovina* and

Artemisia santonicum forms facies. In the open grassy *Artemisio-Festucetum pseudovinae, Bromus mollis* appears with high coverage (BAGI, 1988b).

Towards the higher reliefs, transitional stands of *Artemisio-Festucetum* and *Achilleo-Festucetum pseudovinae* have developed on leached soils. These units show a degradative character. The ubiquitous weeds (primarily *Bromus mollis*) have a high coverage. These degraded territories can be found near the northern and southern boundaries of the core area, forming strips about 50—60 m wide.

In the highest reliefs of the core area, elements of three basic associations *(Achilleo-Festucetum pseudovinae, Potentillo-Festucetum pseudovinae* and *Astragalo-Festucetum rupicolae)* can be recognized. The anthropogenic, strongly degradative *Cynodonto-Poetum angustifoliae* and *Cynodonto-Festucetum pseudovinae* are often associated with them. These associations form transitions. Exceptional in this respect is the vegetation of a steeply protuberant, isolated ridge with its typical *Potentillo-Festucetum* and *Astragalo-Festucetum rupicolae* associations in the south-western part of the core area. This is surrounded by stands of the *Lepidio-Puccinellietum* association. A small population of *Iris pumila* can be found only here within the core area. Unfortunately, another ridge in a similar position has degraded vegetation. Therefore, the undisturbed territory needs increased protection.

The size of territories with degraded vegetation is well reflected by the occurence of *Bromus mollis*. Its coverage may be high in the *Achilleo-, Potentillo-* and *Artemisio-Festucetum* associations. The stands of vegetation with a high coverage of *Poa angustifolia* can also be regarded as degradative.

2. RECOMMENDATIONS FOR PROTECTION OF THE VEGETATION AND UTILIZATION OF THE CORE AREA

The lack of water is the general factor which seriously affects every community. Moreover, the short-term survival of some communities is endangered. The lack of water has two components: the lack of surface water and the increased sinking of the water-table. There is no practical solution to the problem of the lack of surface water because there is no appropriate canal near the core area from which the lack of rainfall could be compensated. The most important causes of the sinking of the water-table can be ascribed to the inappropriate water management (BAGI, 1988b). The water-consuming effect of the surrounding gravel-pits is also appreciable (cf. HERKE, 1983). The gravel-pits are expanding towards the core area. The authorization of new pits nearer the core area is undesirable. Besides the effects of these pits on the water-table, the noise and air pollution are also disadvantageous for the territory.

In the territory, there is a complicated network of disused canals. They are really incongrous scenically, but their levelling is not a feasible proposition. The reparation work would have harmful effects on the vegetation, and for years subsequently only ruderal vegetation would develop in place of the canals. Further,

the territories separated from one another by canals may be the objects of isolated experimental investigations. It is also of importance that the canals do not permit vehicles to be driven across the core area. The problem of such passage arises strongly in the earlier studied core areas (BAGI, 1987; 1988a).

The natural depression (oriented in a NW—SE direction)divides the core area into two parts which differ significantly from one another. The large stands of *Artemisio-Festucetum* and *Agrostio-Alopecuretum agropyretosum* need increased protection on the eastern side. These large vegetational blocks are able to preserve the biocenoses characteristic of them. The dominant association on the western side is *Lepidio-Puccinellietum limosae*. Unfortunately, a significant proportion of this community is outside the declare core area. If these territories were annexed to the core area, the area would not be more than 20% bigger. Hereby, territory with increased protection would be formed, in which two such characteristic communities of the Hungarian saline plains as *Artemisio-Festucetum pseudovinae* and *Lepidio-Puccinellietum limosae* would have closely similar extents.

The most urgent environmental tasks require not a local, but a regional solution. At the same time, local measures are needed to prevent the impairment of the vegetation from reaching such a degree that the degradative processes become irreversible.

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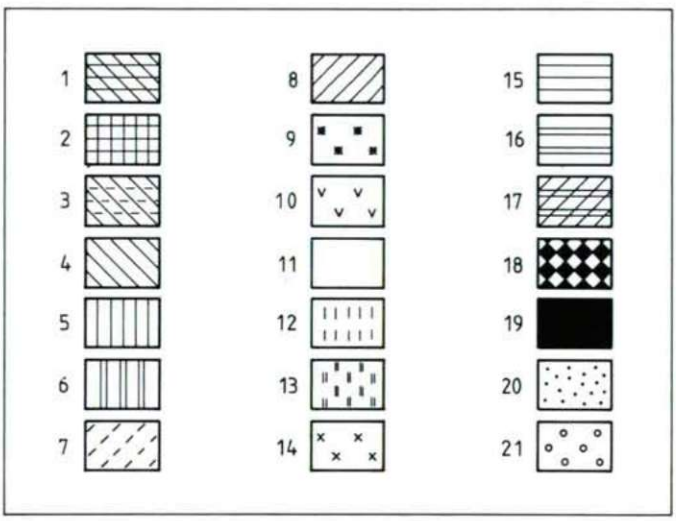
Appendix

Key for identification of the units of the vegetation map of the Tripolisz UNESCO biosphere reserve core area: 1. *Caricetum acutiformis-ripariae caricetosum acutiformis;* 2. *Caricetum melanostachyae;* 3. *Astero-Agrostetum stoloniferae Bolboschoenus maritimus* facies; 4. *Astero-Agrostetum typicum;* 5. *Agrostio-Caricetum distantis;* 6. *Agrostio-Alopecuretum pratensis agropyretosum repentis;* 7. *Lepidio-Camphorosmetum annuae;* 8. *Lepidio-Puccinellietum limosae;* 9. *Caricetum divisae;* 10. *Artemisio-Festucetum pseudovinae* x *Lepidio-Puccinellietum limosae;* 11. *Artemisio-Festucetum pseudovinae typicum;* 12. *Artemisio-Festucetum Hordeum geniculatum* facies; 13. *Artemisio-Festucetum Podosperum canum* facies; 14. *Artemisio-Festucetum Artemisia santonicum* facies; 15. *Artemisio-Festucetum* x *Achilleo-Festucetum;* 16. *Achilleo-Festucetum;* 17. *Achilleo-Festucetum* x *Potentillo Festucetum;* 18. *Potentillo-Festucetum pseudovinae;* 19. *Astragalo-Festucetum rupicolae;* 20. *Bromus mollis* facies; 21. *Poa angustifolia* facies.

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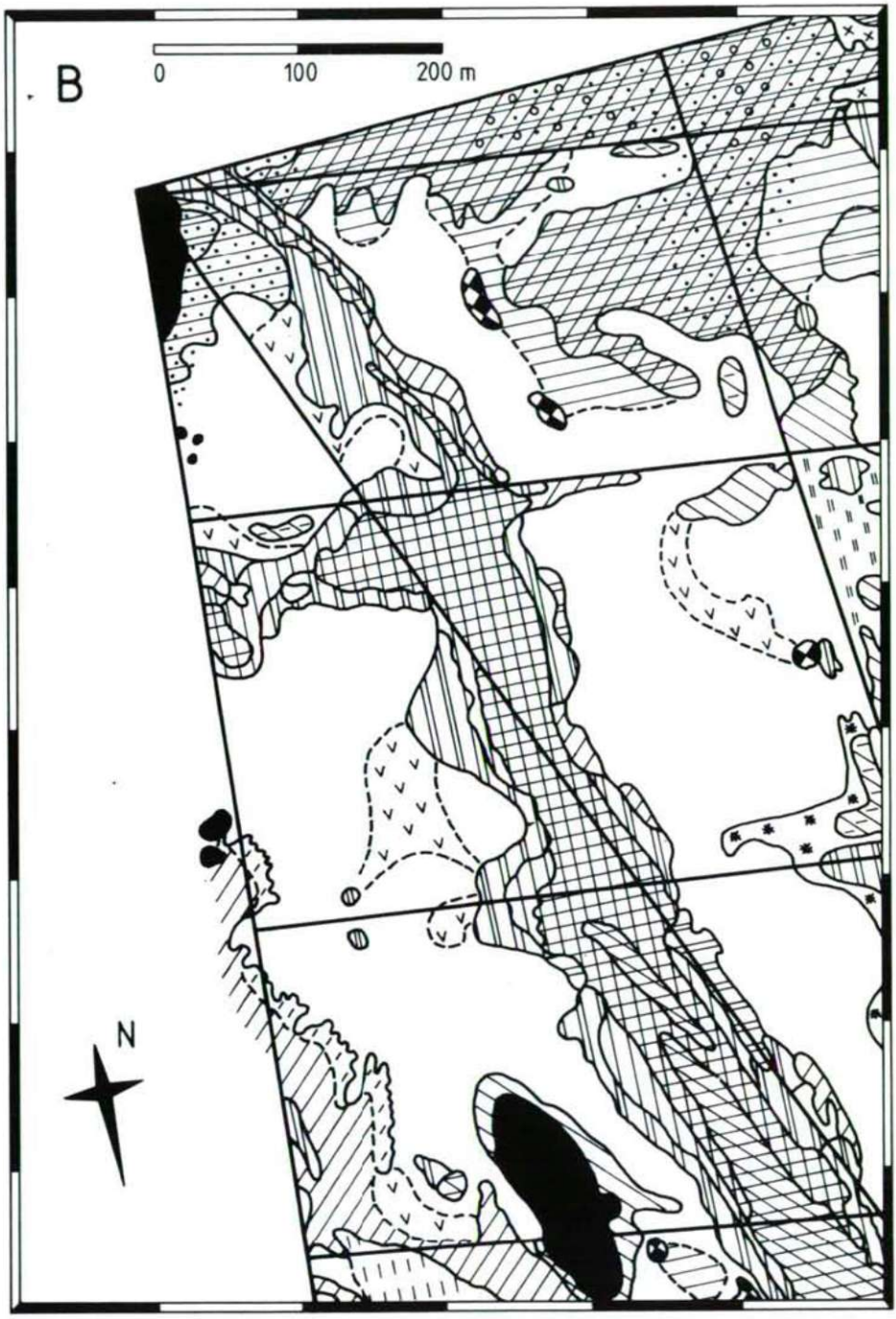
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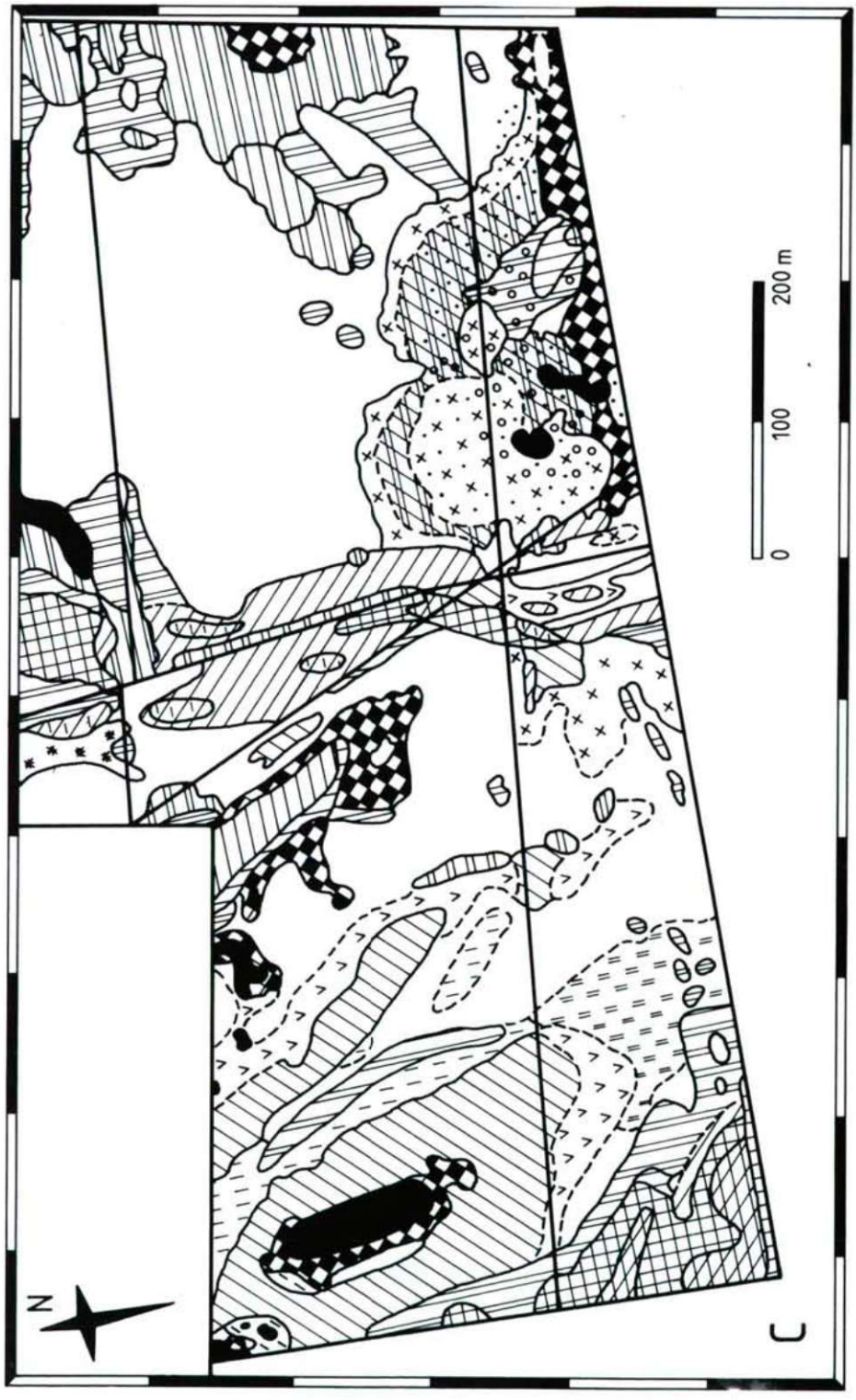
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A STRUCTURAL MODEL OF THE SPOROPOLLENIN BASED ON DODECAHEDRANE UNITS

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Abstract

In this paper the first structural model for the basic biopolymer skeleton of the sporopollenin is presented. Modeling the biopolymer system of the sporoderm is based on the TEM result of partially degraded exines. This first structural approach offers new aspects for the further experiments for degradation, in particular concerning the solvents used.
Key words: Sporopollenin, biopolymer skeleton, structural model.

Introduction

For the biopolymer organization of the spore-pollen wall several stages were established (KEDVES, 1987a). As the basic biopolymer unit of the sporoderm, a regular pentagonal figure of Å dimension (8—12 Å) forming a quasi-crystalloid lattice was found (KEDVES, 1988). The highly organized levels may be of different types in nanometer dimension (e. g.: helical, ROWLEY et al. 1980, 1981, tubular, ROWLEY et al. 1987, granular, KEDVES et al. 1974, irregular polygonal, SOUTHWORTH, 1985, 1986, etc.).

In spite of these achievements, a constant need is felt to find an adequate model which would organize our notions on the sporopollenin into a coherent scheme. Our hope is that the present contribution will be a first step in this direction. The structural model proposed here is based on elementary stereochemical considerations.

The model and its consequences

Our starting point is a polycyclic alkane molecule of nearly spherical form, called a dodecahedrane (BARTON, 1979). This name refers to its geometry, as the carbon atoms are located in the vertices of a regular pentagonal dodecahedron. The latter is one of the five regular (Platonic) solids (COXETER, 1961): it has twelve regular pentagonal faces and twenty vertices such that each vertex is connected to three adjacent vertices (Fig. 1a). Thus, every edge corresponds to a C—C bond and the fourth valency of the C atoms is directed outwards each bonding a hydrogen atom (not indicated, by convention, in Fig. 1a).

Each face of this $C_{20}H_{20}$ molecule can be regarded as a cyclopentane skeleton with perfect pentagonal symmetry (Fig. 1b) (accepting for simplicity, or as a first approximation that the dodecahedrane molecule exhibits full icosahedral symmetry, i. e. its symmetry group is Y_h). In this case at the C—C bonds an angle strain of 1°28' occurs which corresponds to the difference between the tetrahedral angle 109°28' and the inner angle 108° of a regular pentagon.

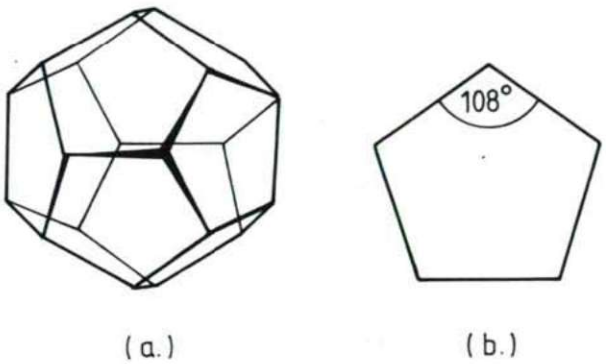

Fig. 1. The regular pentagonal dodecahedron: the skeleton of the dodecahedrane molecule (a) and one of its faces (b) with the characteristic bond angle indicated.

Before passing over to the next organization level, we refer to a geometric peculiarity of the regular pentagonal dodecahedron, namely that a (regular) tetrahedron can be inscribed in a manner shown in Fig. 2. The consequence is that we have additional tetrahedral bonding directions. The next step is to link five dodecahedrane molecules together along these directions forming a larger pentagonal unit (Fig. 3).

We have taken the liberty of naming this large-sized pentagonal unit giving it the name *pentasporane*.

The consequences deduced from our model are as follows.

1. The first and perhaps the most important fact to an experimentalist is the size of the pentasporane unit. It is rather close to 12 Å as one can easily check on Fig. 3 supposing the well-known C—C bond length of 1.54 Å. Thus, this unit can be identified with that earlier called "quasi-crystalloid pentagon" and considered to be the primary building block of the sporopollenin structure.

2. The building principle described above can be applied in an iterative manner. For, starting from a small pentagon (of the cyclopentane) we obtained a larger pentagon (the pentasporane). But this new pentagon can also be organized into a larger dodecahedral unit and hence an even larger pentagon can be obtained, and so forth (but not ad infinitum, see below).

3. We find it reasonable to suppose our model units may well explain various other morphological elements found in TEM pictures at different organization levels, like for example helical substructures. Work in this direction is in progress.

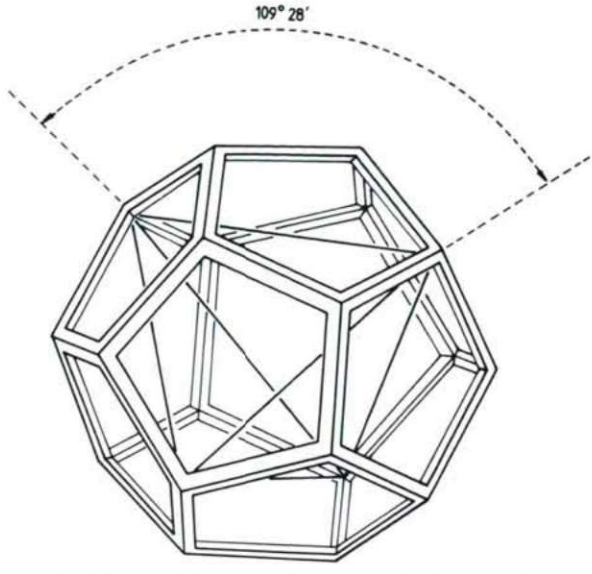

Fig. 2. Inscribing a regular tetrahedron into the regular pentagonal dodecahedron (one tetrahedral angle is indicated).

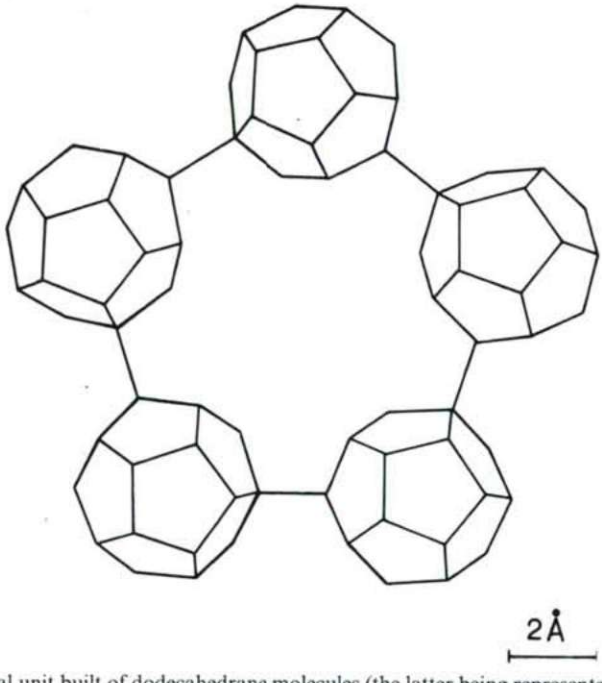

Fig. 3. A pentagonal unit built of dodecahedrane molecules (the latter being represented, for simplicity, as polyhedra with non-transparent faces).

4. Dodecahedrane may be thought of as breaking down into various acyclic and cyclic alkane components in numerous different ways, like e. g. to 2 cyclopentane + 1 decane ("sandwich-like decomposition"), or to 5 butanes, or to 2 methanes + 3 2,3-dimethyl-butanes, etc. This and the principle "similia similibus solvuntur" suggest that simple saturated hydrocarbons related to dodecahedrane in this way may serve as suitable solvents for the usual degradation experiments.

5. As mentioned above, the supposition of perfect (icosahedral, Y_h) symmetry in the dodecahedrane unit implies 1°28' angle strain per one C—C bond. This strain accumulates as the organization proceeds passing over to higher levels. For example, for the dodecahedrane it amounts to 44°. This value in the pentasporane will be multiplied by five and completed by $5 \times 1°28' = 7°20'$ (due to the bonds linking together the dodecahedral units): altogether 227°20'. It is clear that the cumulative strain tends to destabilize the system and this is why our building principle does not work beyond all limits (cf. the end of paragraph 2).

However, one can suppose that elements of a lower degree of organization can tolerate a moderate amount of strain, and are even in a metastable state of long lifetime (in fact, intercalated units, such as filaments, etc. may contribute to the stabilization (KEDVES, 1989).

A peculiar phenomenon described earlier (KEDVES, 1987b) may be explained by the supposition of ceasing this endurance, namely the explosion of the pollen grains under scanning effect. The energy fed into the specimen by the scanning electron beam can release the built-in strain in a concerted manner, by synchronous opening of the C—C bonds. (This process, in some of its features, shows close resemblance to the ablation effect of polymers under laser irradiation (KISS and SIMON, 1988). Perhaps explosion of a single dodecahedrane unit ("molecular explosion") is sufficient to initiate the whole explosion.

Conclusions

The need for structural modeling the biopolymer organization of the sporoderm was emphasized above. The present attempt is the first one in this respect. It resulted in new suppositions, as well as suggestions for the partial destruction of the sporoderm. In this way we hope to get direct (TEM) data about the higher organized (e. g. helical) units. The latter, in turn, would serve as a starting point for further structural modeling based on the concepts introduced here.

This work was supported by the grant OTKA II—24/88.

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QUASI-CRYSTALLOID BIOPOLYMER STRUCTURES OF THE SPORODERM AND ITS HIGHLY ORGANIZED DEGREES

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Abstract

In this paper a new comprehensive model is presented for the biopolymer organization of the sporoderm. The basic biopolymer unit is bordered by regular polygons, which forms a quasi-crystalloid skeleton. On the basis of our up-to-date knowledge, three degrees may be distinguished at the highly organized biopolymer units of the sporoderm.
Key words: sporopollenin, biopolymer, quasi-crystalloid structure, organizations model.

Introduction

The extremely resistant substance of the wall of the spores and pollen grains has been the subject for a long time of several kind of investigations. The first data on the chemistry of the sporoderm were published by JOHN (1814) and BRACONNOT (1829). Later, in the thirties ZETZSCHE and his collaborators achieved important results in the elaboration of several problems in detail. For example, ZETZSCHE and KÄLIN (1931) established the autoxydation of the sporopollenin, in consequence of illumination. The first, so-called classical results were reviewed by TOMSOVIC (1960), and following this concept, the sporopollenin is a highly polymerized terpene derivate, similar to the cutin. Later, BROOKS and SHAW (1986a, b) fundamentally changed the earlier concepts, and established the basic importance of the β carotene and its esters in the biosynthesis of the sporopollenin. BROOKS and SHAW (1978) emphasized that probably the sporopollenin is the most resistant organic matter, originated directly in biological way. The most important modern concepts concerning the chemistry of the sporopollenin may be summarized as follows:

1. The basic compounds of the sporopollenin on the one hand are β carotene and the oxidizing esters of carotenoids, and on the other hand aromatic lignin derivates. The lignin derivates are of stabilizator importance; cf. MANSKAYA et al. (1973).

2. Newly, the precursor importance of the phenylalanine was established at the pollen grains of the genus *Tulipa* by RITTSCHER et al. (1987). Structurally integrated phenol derivates were found after the quantitative analysis of the sporopollenin isolated from the pollen grains of *Pinus* genus; SCHULZE et al. (1987).

3. Lipopolysaccharide filaments, embedded in the exine, were described by ROWLEY (1975).

4. Concerning the lipid fractions of the recent and fossil sporomorphs, a paper by DUNGWORTH et al. (1971) is important.Carbohydrates, alcohols and fatty acids were the components of the extracts.

5. Silicons, cations, in all probability in organic binding are present in the sporoderm. ROWLEY (1971) published about the thorium accumulation on the surface of the sporoderm.

6. The chemical compounds of the different exine layers are not identical; cf. FORD (1971).

7. In connection with the diagenesis of the sporopollenin, the accumulation of the lignin derivates may be stressed; cf. POTONIÉ and REHNELT (1971).

Resuming the knowledge of the chemistry of the sporopollenin may not be taken as a settled question, several new results may be presumed. Concerning the new trends of investigations, the electrostatic charge of the sporoderm surface may be pointed out, as a particularly interesting problem. Probably, the citation, taken from the paper of GUILFORD et al. (1988) well represents the present day statement of this question; p. 135: "Sporopollenin is therefore a class of biopolymers rather than a single, homogeneous macromolecule. The appearance of the spectra is more supportive of a fatty acid precursor (long saturated aliphatic chains, low olefinic intensity) than of a carotenoid precursor (significant quaternary olefinic intensity and methyl intensity). Indeed, only the spectrum from the *Lycopodium* spores showed a substantial similarity to that from polymerized β-carotene (spectrum not shown)".

Regarding the physical characteristic features of the spore and pollen wall, the following may be pointed out: ROWLEY and FLYNN (1964) established the migration of lanthanium through the pollen wall, not only in the apertural region. ROWLEY and SOUTHWORTH (1967) in connection with the deposition of the sporopollenin on unit membranes supposed a "paracrystalline molecular system." On the basis of the previous results (migration of the cations, colloidal iron, lanthan, colours as Alcian blue, Ruthenium red) ROWLEY (1973) concluded that exine may be taken as a molecular sieve. ROWLEY (1971) established that the protoplasm of the pollen tetrades is composed of unit membranes (about 200 Å thick) the elemental units of the membranes are fibrils, which adsorbs the cations. The exine surface covering layer, the glycocalyx adsorbs thorium and other cations justifiying the anionic character of the surface.

The first knowledge about the molecular structure of the sporoderm was based on results got with indirect methods. Worth of mentioning are the papers by SITTE (1960), FREYTAG (1964) and others. The methodical basis of the above mentioned researches was the optical anisotropy. The first results obtained with direct, transmission electron-microscope method were published by AFZELIUS et al. (1954), and AFZELIUS (1956). These early results raised two concepts for the molecular organization; the lamellar and the fibrillar respectively. ROWLEY and SOUTHWORTH (1967) described the deposition of the sporopollenin on unit membranes. Following ROWLEY (1967) the lamellae are often composed of five granules, and the diameter of these subunits is approximatively 2 nm. FLYNN and

ROWLEY (1972) established that the primexine is a matrix of polysaccharids, its chemistry differs from the radially oriented probaculi. KEDVES et al. (1974) described spherical sporopollenin biopolymer units from partially degraded exines during the taphonomical processes of angiosperm exines of the Lower Eocene layers of Mississippi. ROWLEY (1975) published lipopolysaccharide filaments form the exine, and concluded that sporopollenin may not be taken as the single component of the exine. It is interesting that he obtained these lipopolysaccharide filaments by dissolving the exine in hot aminoethanol, and aquous phenol solution. ROWLEY et al. (1980) published the helical sub-units of the exine. This paper was followed by several publications of similar subject. SOUTHWORTH (1985a) emphasized that to visualize the exine subunits it is necessary to degrade partially the exine. She described granular units from the exine of *Lilium longiflorum* THUNB., which are composed of irregular pentagons. In another publication she (1985b) published similar results, obtained during the researches on the exine of *Fagus sylvatica* L., and remarked that it was not possible to observe helical structures. Later, SOUTHWORTH (1986b) established that the three components of the sporopollenin are of different solubility, and emphasized that there are numerous data in opposition to the helical model, but as for an opportunity she raised that some of the geometrical polygons may be form arcus. The paper of HESSE (1985) is important, because he described, although from the surface spherical structures of 70—80 nm without experimental degradation.

The aim of the present paper is the following:

The synthesis of our present day knowledge about the biopolymer system and its organization of the sporoderm, revealed by partial degradation under natural or experimental conditions.

Results and discussion

Fig. 1 summarizes the most important types of our model for the organization levels of the sporopollenin. It seemed to be practical to distinguish strictly the precursors, which be investigated with chemical methods, from the biopolymer units which are detectable with the transmission electron-microscope method. On the basis of the concepts, discussed roughly in the introduction, it is clear that the problem of the chemical composition of the spore-pollen wall is newly also very complicated, with several opposing concepts. In this way as symbols, the formules of the carotenoid, carotenoid ester (BROOKS and SHAW, 1973) and a part of the lignin molecule (METZNER, 1973, following the book of TISSOT and WELTE, 1984) are shown in fig. 1.

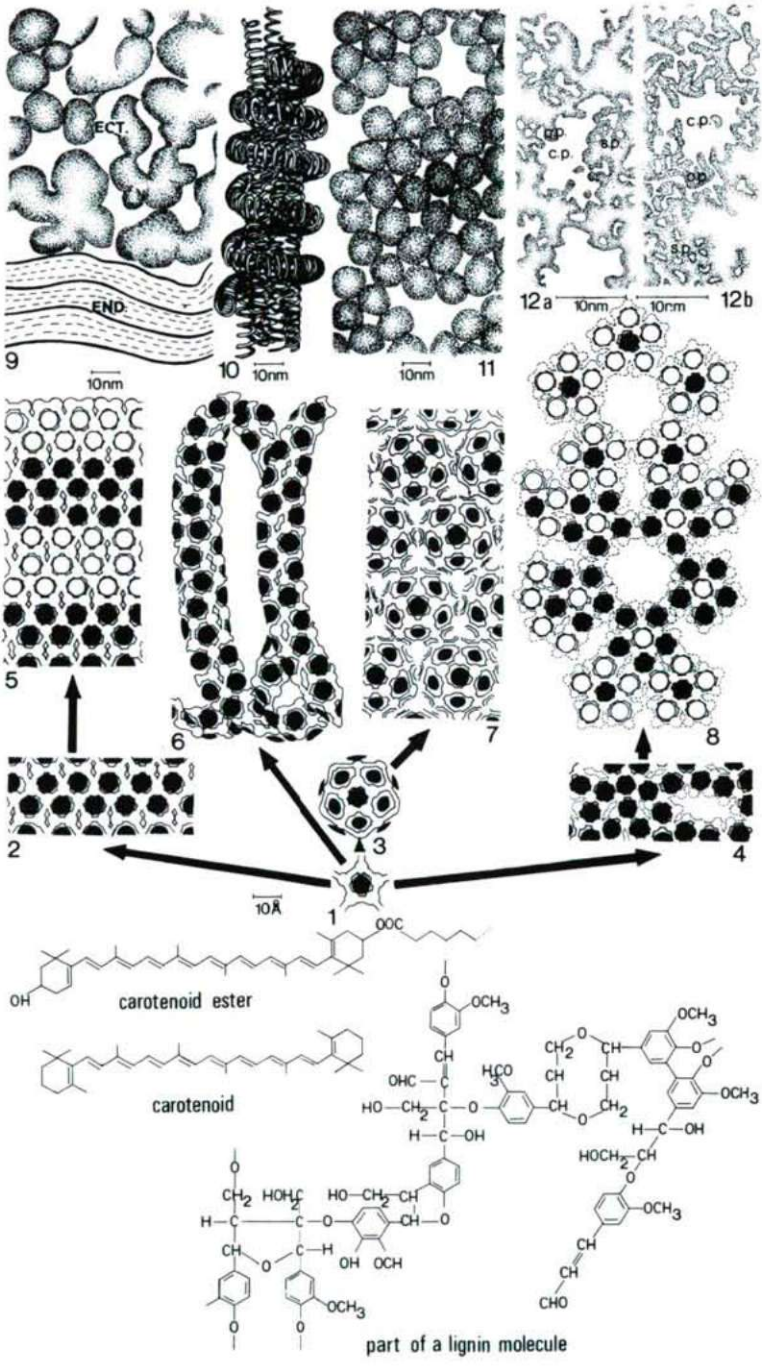
ROWLEY and FLYNN (ex ABADIE et al., 1986—87) published its modell and distinguished two phases:

1. The exine ontogeny; which include the initiation of the precursors of the sporopollenin, and the polymerization of the precursors.

2. The substructure of the exine: The phase, which follows the polymerization, this is essentially the field of our investigation.

Among the results obtained so far by different methods those of the partially degraded exine of *Taxus baccata* L. (KEDVES, 1987) may be regarded as important in this respect. After experiment the originally lamellar endexine got a network-like structure, among which regular pentagonal polygon units may also be recognized (p. 164, fig. 2). The diameter of these units is 8—12 Å. In this way, taking into consideration the model of ROWLEY and FLYNN (cf. ABADIE et al., 1986—87), mentioned previously, in the organization series, after the exine ontogeny the basic biopolymer unit is the following, and from this may originate further substructures of the exine. Later the quasi-crystalloid character of the pentagonal basic units was published, KEDVES (1988). This raises fundamentally the problems of symmetry in this relation. In this paper we shortly touch this problem, because numerous further researches are in progress, or a program under elaboration. The writer, before recognizing the results of Mathematics and Crystallography, attached to this problem, as a model in the autumn of 1987, Fig. 2. was compiled, which was naturally based on results obtained of the partially degraded exines of the pollen grains. In this manner on a completely different basis I came essentially to the same

Fig. 1.
The organization levels of the sporopollenin.
Among the chemical compounds the part of the lignin molecule follows METZNER (1973) from the book of TISSOT and WELTE (1984). Carotenoid and carotenoid ester, after BROOKS and SHAW (1973).
1 — Scheme of the basic molecular unit of regular pentagonal symmetry. At the vertices there are spherical units, connected with tiny arms. In the central point there is also a spherical unit, which differs in electron density from the above mentioned, similarly spherical units.
2,5 — Molecular interpretation of the lamellar ultrastructure. The central spherical units are ordered in lines, in consequence of the alternative disposition of the basic biopolymer units. The streaked, regular change of the electron density of the central molecular units results in submicroscopical lamellae.
9 — *Balmeiopsis limbatus* (BALME 1957) ARCHANGELSKY 1977. Schematic drawing from the picture of the exine. The ectexine is composed mostly from isodiametric elements, which anastomose, forming irregular structures. The endexine is lamellar inside the larger lamella, there are more, not so characteristic narrower lamellae. ECT = ectexine, END = endexine.
6 — Scheme of the presumed molecular structure of one elementar part of the helical and tubular subunit.
10 — Scheme, redrawn from the paper of ROWLEY (1981, p. 359, fig. 1) — "Wire-wound model of a portion of a "tuft" unit of the exine." (ROWLEY, 1981, p. 358).
3 — Scheme based on the results published by KEDVES et al. (1974) from the spherical biopolymer units of 15—30 Å in diameter.
7 — Ordered or disordered heap of the units represented in the above discussed scheme (3).
11 — Spherical units of nanometer dimension, on the basis of our up-to-date knowledge forming combined izodiametric units. Scheme based on the publication of HESSE (1985).
4 — Molecular scheme of the irregular polygons in nanometer dimension. In consequence of the dissolution of the regular and/or irregular biopolymer skeleton, holes appear in the exine.
8 — Scheme of the quasi-crystalloid structure of the polygons of nanometer dimension.
12a — Drawing made from fig. 8, p. 66 of SOUTHWORTH (1986b): "*Juniperus communis* extracted 16 min. Arms protrude at open polygons; single and compound polygons occur."
12b — Drawing made from fig. 7, p. 66 of SOUTHWORTH (1986b): "*Fagus sylvatica* extracted 16 min. showing angular open polygons with arms protruding at the surface." s. p. = single polygon, c. p. = compound polygon, o. p. = open polygon.


ECT.
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9
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7
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2
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1
10Å
carotenoid ester
carotenoid
part of a lignin molecule

result, which was published earlier by mathematicians, crystallographers, and chemists. Recently from the so-called "non-biological papers" the following were taken into consideration: MACKAY (1976, 1981), PENROSE (1979), SONIN (1981), BURSILL and PENG JU LIN (1985), SACHDEV and NELSON (1985), AUDIER and DUYOT (1986), GÉVAY (1986), HEILBRONNER (1986), NELSON (1986), O'HANDLEY (1987), SCHNEER (1988). In connection with the evolutionary symmetry of the early angiosperm flower, very valuable information was published by ENDRESS (1987).

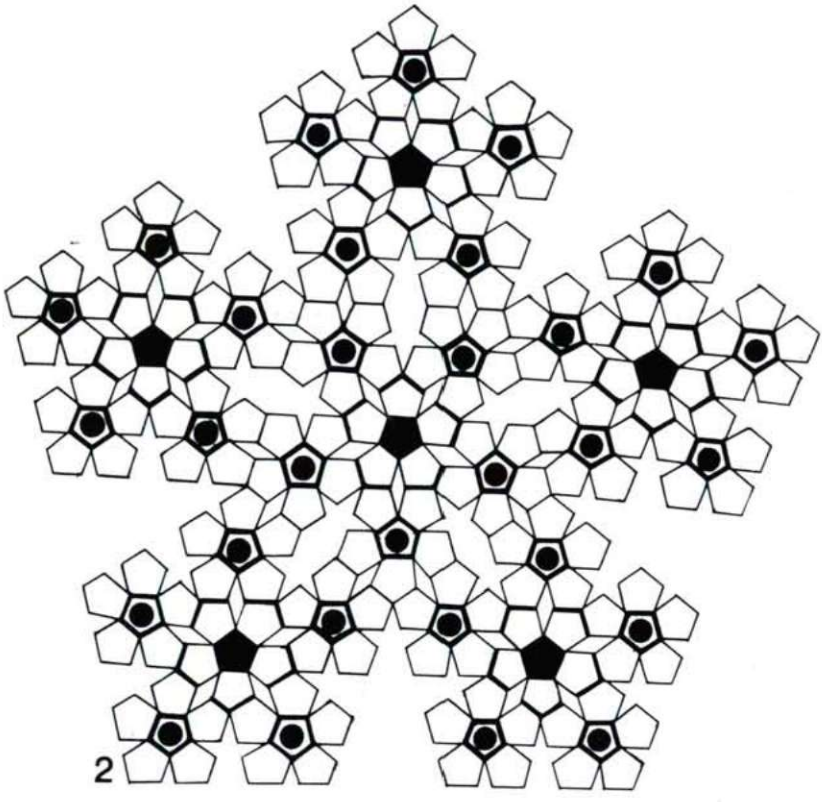
Using several modified variants of the Markham rotation (cf. HORNE and MARKHAM, 1972) concerning the symmetry of the biopolymer organization of the sporoderm, several new results were obtained. At present, that of the regular pentagonal polygons as basic units of the skeleton of the sporoderm may be considered as undoubted. But it is necessary to remark that probably this is not the only component of the basic biopolymer skeleton. Special problems of this method and the detailed results will be the subject of further papers.

One side of one unit of the basic skeleton is a form of regular pentagonal polygon. At the vertices there are globular units which are connected with short arms. In the centre of the polygon there is also a spherical unit, but in general, the electron density of the two kinds of spherical units are different (fig. 1; 1). The experimental process, by gradual solution and/or oxidizing cleared from the hollows of the basic skeleton further components, the chemistry of which is not known exactly at present.

The next level in the biopolymer organization of the exine is represented in fig. 1; 2—4. We have TEM information from the types as follows: Lamellar (fig. 1; 2), globular (fig. 1; 3), and open biopolymer structures (fig. 1; 4). On the basis of our up-to-date knowledge, the helical sub-unit may be originated directly from the basic biopolymer unit.

In the case of the lamellar arrangement of the basic biopolymer units, the central spherical elements form more or less regular lines. In this respect, our results (Kedves and Winter, in print) are worth of mentioning. Fibrills may also be presumed, which are oriented in lamellas. But further researches will be decide whether oriented fibrills forms really the lamellas. The molecular interpretation of the transmission electron-microscope method is well represented in fig. 1; 5. The electron density of the globular units surrounded by regular pentagonal polygon biopolymer units alter streakly. In this respect we have more data, as a good example the results obtained on *Abies concolor* HOOPES may be mentioned. The originally homogeneous foot layer after experiment became lamellar. This characteristic feature is of an early type, which in original form occur at the saccate gymnospermatophyta pollen grains of the Paleo- and Lower Mesozoic sediments. The inner layers; foot layer and/or endexine are in general of lamellar ultrastructure.

Fig. 2.
1. Scheme of the arrangement of the regular pentagonal units of one centrum.
2. Scheme for the quasi-crystalloid biopolymer units.



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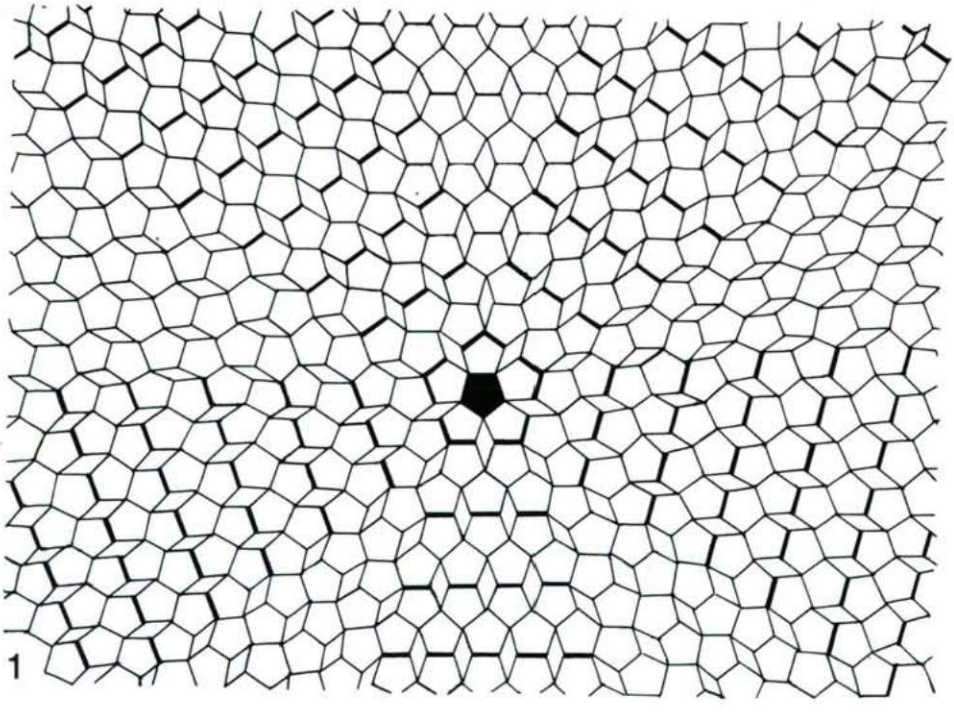

1

Based on the biopolymer model of the lamellar structures in nanometer dimension, this may be easily interpreted. As an example the scheme was given; fig. 1; 9, which was drawn from the TEM picture of a fossil mesozoic gymnosperm pollen grain — *Balmeiopsis limbatus* (BALME, 1957) ARCHANGELSKY, 1977. In this way, among the two early types discovered in the course of the ultrastructure-phylogenetical researches of the exine, in particular the lamellar is well known from this point of view. As regards the biopolymer organization of the spongy exine, composed of irregular rods of sporopollenin, till this time, we have no information. The experimental study of the wall of the early fossil spores from different geological ages will bring surely interesting information from this point of view.

As we have referred previously, the helical substructures of the exine may come from the basic pentagonal polygon biopolymer unit. For the moment it is only a supposition, that in Angstroem dimension a network of regular pentagonal polygon units constructs the elements of the helical substructures, fig. 1; 6, Fig. 1; 10 was redrawn from the paper of ROWLEY (1981). For the present day knowledge of this concept, in nanometer dimension it is important to cite from the model of ROWLEY and FLYNN (ex ABADIE et al., 1986—87) in the following; p. 2:

"b Exine substructure
o Exine unit — tuft = complex tubular assembly
(ca 70 nm diam.) (HIDEUX & ABADIE, 1985)
core subunits (ca 5 separate subunits)
oo Exine subunit
(diam. 10 nm)
binder subunit
ooo Elements of subunit (fig. 12a)
(10 elements or double helical elements)"

In connection with the spherical units of the exine, it is necessary to emphasize that on the basis of our up-to-date knowledge, we can distinguish at least two functional types:

1. structural, respectively, 2. superficial, sculptural elements. The spherical units of 15—30 Å in diameter may easily come from the basic unit (fig. 1; 3). During the transmission electron microscopical study of the partially degraded exine of fossil palynomorphs, globular units of sporopollenin of 15—25 Å were firstly described (KEDVES et al., 1974, KEDVES, 1986a, b). On the globular biopolymer units of the fossil angiosperm pollen exines discovered by the taphonomical processes during the sedimentation, inside of the globular units here and there the regular pentagonal basic skeleton may also be perceptible. The investigation of these units with the Markham rotation is a coming program. The higher structural organization of the spherical unit delineated in fig. 1; 3, is not sufficiently known at present. Probably as an early characteristic feature it is an irregular heap. Concerning the superficial spheric units, the paper of HESSE (1985) must be pointed out. The smaller, spherical sporopollenin-biopolymer-units form larger likevise spherical heaps in nanometer dimension (fig. 1; 11).

The interpretation on molecular basis, the results of SOUTHWORTH (1985a, b, 1986a, b) by gradual solution, and degradation of the exine described the irregular polygons, which form a lattice. The molecular interpretation of the irregular polygons, forming another kind of biopolymer skeleton is well shown in fig. 1; 4, 8. Its two dimensional model is represented in fig. 2; 2. The basic quasi-crystalloid structure and the solubility characteristic features of the exine refer to two different kinds of "seed crystals" during the biopolymer ontogeny of the sporoderm. Cf. SOUTHWORTH (1986b), p. 67: "A possible explanation for the sequence of changes in the eroding exine is that the sporopollenin of the mature exine may consists of materials with three different solubilities in 2-aminoethanol with two of these materials removed to produce the pattern show here." These and the connected units react in different manner upon the taphonomical and experimental processes. This results in the single polygon (s. p.), compound polygon (c. p.) and the open polygon (o. p.), fig. 1; 12, a, b). In this way not only biochemical, but biophysical, a sensu stricto biocrystallographical attitude is necessary to the sufficiently extensive interpretation of the sometimes purely biological phenomena.

In the following we touch shortly those exine structures, and their position in the biopolymer organization, which are not represented in fig. 1.

MICROCHANNELS

The microchannels may be ranked among the helical biopolymer organization, taking into consideration their dimension, and their fine structure. Particularly interesting is the documentation in Plate 4. in the paper of ROWLEY et al. (1987). This kind of biopolymer structure may be characterized the following citation: "We proposed as a result of analyses of the patterns of stained substances within exines that microchannels occur either in microcapillary spaces between units or as a part of the substructurae within units of the exine (ROWLEY and EL-GHAZALY, 1980). Exine-unit structures, according to the model of ROWLEY et al. (1981), are a complex of 10 nm wide substructures arranged in a cylinder of variable diameter although they are commonly 70—150 nm."

ROWLEY UNITS

This biopolymer organizing unit was described first from the partially degraded wall of the *Botryococcus algue* from the oil shale (KEDVES, 1986a). This is a kind of units in nanometer dimension, its place and its nearer morphology is as yet problematic. It is possible that these are extremely short microchannels, thus a type of the helical organization.

UBISCH BODIES (= orbiculi)

These are superficial elements, and belong not closely to this problem. But Ubisch bodies occurred during our experiments too, and it was necessary to investigate their biopolymer system, too. In connection with thiss question the comprehensive paper of ROWLEY and WALLES (1987) must be pointed out.

Final conclusions

1. Several organizations levels of the biopolymer system of the sporopollenin can be distinguished, and between the highly organized units some types can be recognized.

2. The highest level of the biopolymer organization of the sporopollenin is the homogeneous exine.

3. In further researches to better understand the biopolymer organization of the sporoderm geometric, crystallographical modelling is necessary.

4. The multidisciplinary character of this field of research must be stressed. The use of further non-biological methods assure new opportunities, e. g.:the use of the X-ray diffraction method.

Acknowledgements

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INVESTIGATION OF THE BIOPOLYMER ORGANIZATION OF PARTIALLY DEGRADED EXINES WITH THE FRAGMENTATION METHOD

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Abstract

Pollen grains of *Alnus glutinosa* (L.) GAERTN. were partially degraded by ten different kinds of experiments. The partially degraded exines were fragmented and the residues were investigated with transmission electron microscope. On the basis of our first results, the advantages and the limits of this method are discussed in this paper. Advantages: There are opportunities to study the different levels of the sporoderm organization in the dimension of the molecules. 2. The biopolymer basic-units could be investigated in the entire exine structures. 3. Highly organized biopolymer structures of different morphology were also to be observed: globular and network structures, mostly built from these, respectively filamentous units, too. The latter ones might be well interpreted by the quasi-crystalloid character of the basic-units of the biopolymer skeleton. Limits: In some cases at interesting or peculiar TEM biopolymer structures there may be doubts concerning their origin.
Key words: Palynology, sporopollenin, biopolymer organization, fragmentation method.

Introduction

Relatively few papers deal with the biopolymer structure of the partially degraded sporoderm (e. g.: ROWLEY, 1975; ROWLEY and PRIJANTO, 1977; ROWLEY et al., 1980; SOUTHWORTH, 1985, 1986; KEDVES, 1988a, b). The ultra-thin sections of the partially degraded sporoderm were investigated with transmission electron-microscope. Later, the observed regular pentagonal polygon basic units were investigated with the modified Markham rotation method (cf. KEDVES et al., 1989). In this case this method was not only verificatory for symmetry. The importance of the problem investigated, and in some place its novel character need to elaborate new or adapt other methods of different fields. The new combination of methods represent one part of this attempt, with the first results.

Material and Methods

The objects of our investigations: pollen grains of *Alnus glutinosa* (L.) GAERTN., were collected on 25 February 1989 in the Botanical Garden of the A. J. University, by Dr. K. MARGÓCZY. After collection the fresh material was frozen at -20 °C to eliminate the alternations, which may happen in consequence of

the autoxidation character of the sporopollenin. For the partial degradation of the exine the following experiments were applied:

235. — 20 mg pollen + 1 ml 2-aminoethanol, temperature 30 °C, length of time 24^h.

236. — 20 mg pollen + 1 ml 2-aminoethanol, temperature 30 °C, length of time 24^h + 10 ml KMnO4 aq. dil., 1%, temperature 30 °C, length of time 24^h.

237. — 20 mg pollen + 1 ml 2-aminoethanol, temperature 30 °C, length of time 24^h + 10 ml KMnO4 aq. dil. 1%, temperature 30 °C, length of time 48^h.

238. — 20 mg pollen + 1 ml 2-aminoethanol, temperature 30 °C, length of time 24^h + 100 ml KMnO4 aq. dil. 1%, temperature 30 °C, length of time 24^h + 2 ml acetic acid anhydride, temperature 30 °C, length of time 24^h.

239. — 20 mg pollen + 1 ml 2-aminoethanol, temperature 30 °C, length of time 24^h + 10 ml KMnO4 aq. dil. 1%, temperature 30 °C, length of time 24^h + 5 ml methanol, temperature 30 °C, length of time 24^h.

The pollen material of the experiments No 250—254 were heated at 100 °C during one hour before the solvent and oxidizing process described formerly. This is the only difference between the two series of experiments. The samples of the experiments No 240—249 were not investigated with the fragmentation method. After the partial degradation of the pollen grains the residues were washed in distilled water. The fragmentation was made with a magnetic stirrer in watered medium, during 30 minutes. The fragmented exines were dropped on a grid cowered with collodium pellicle and then dried. The electron microscopical investigations were made on a Tesla BS-500 transmission electron microscope, resolution 6 Å. The modified Markham rotation method was applied at the TEM pictures where the experiments discovered well the basic, regular pentagonal polygon biopolymer units.

Results

Our results are presented in the order of the experiments: 235. — It is surprising that no matter for evaluation was found after this experiment.

235. — (Plate I, fig. 1—5, plate II). In contrast to the previous one we obtained data for attention, which are different in character. Besides disclosing the basic biopolymer skeleton of regular pentagonal polygon units its highly organized level may be pointed out at this experiment. We observed filamentous units too, which are 25—35 Å large (Plate I, fig. 1, 3) on which occur fragments of darker electron dense biopolymer systems (Plate I, fig. 1, marked with an arrow). The basic pentagonal polygon system is partially larger than those recognized previously

Plate I

1—7. *Alnus glutinosa* (L.) GAERTN.

1. Experiment, No 236, filamentous units on it with regular pentagonal polygon biopolymer units, with strong electron density, marked with an arrow, x150000.

2. Experiment, No 236, the highly organized biopolymer units forming a network. Well shown is the pentagonal polygon basic-skeleton, and the spherical units, which built them, x150000.

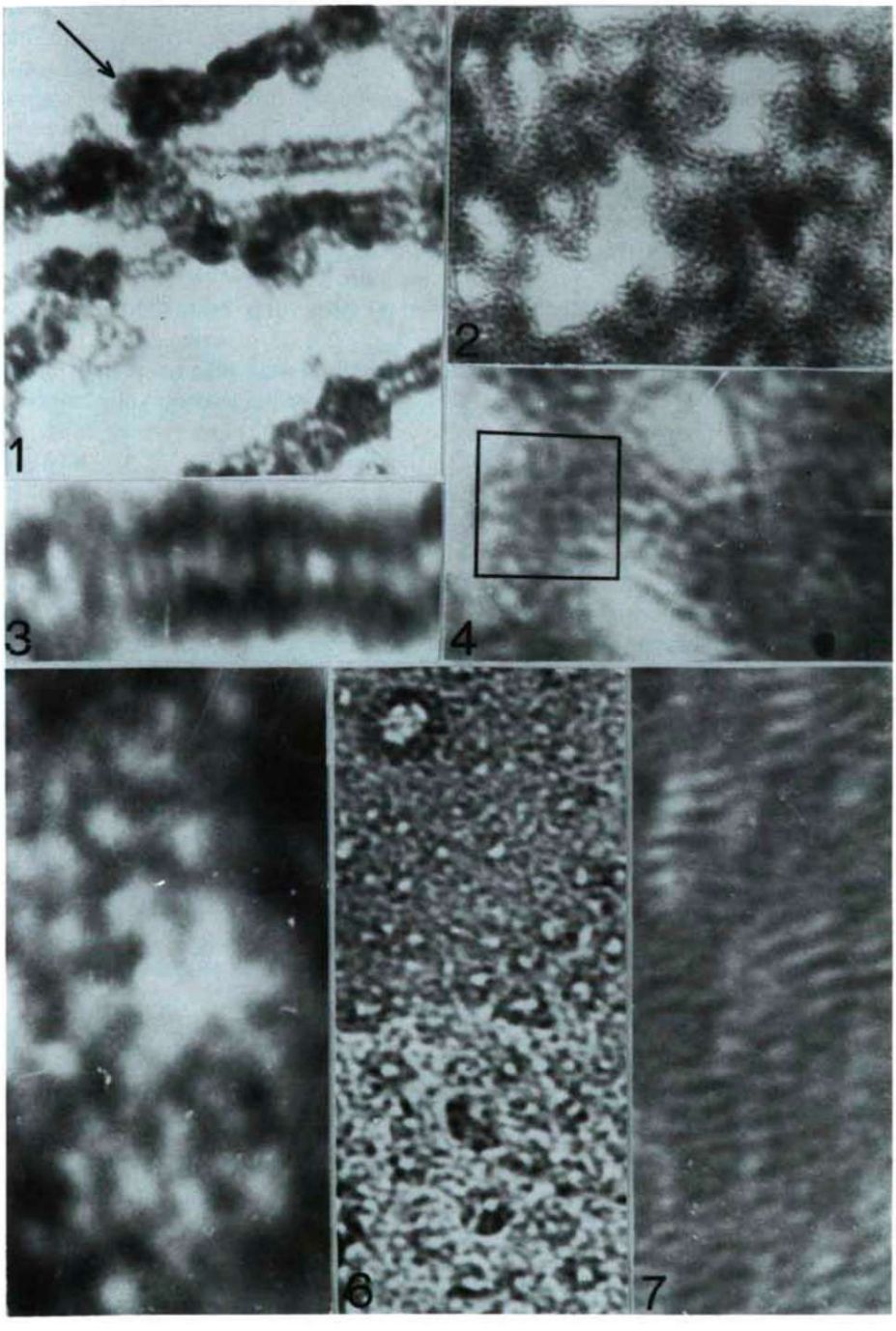
3. Experiment, No 263, detail from the filamentous unit. x500000.

4. Experiment, No 236, detail from the highly organized biopolymer structure forming a network. The central biopolymer unit, which is surrounded with further ones is framed, x500000.

5. Experiment, No 236, detail from the basic biopolymer skeleton, x500000.

6. Experiment, No 237, fragment of doubtful origin, its ultrastructure may be studied on two levels. The darker part is the outer, the bleacher one represents the inner structure, x250000.

7. Experiment No 237, helical structures from a vegetal fragment of doubtful origin, x500000.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(Plate I, fig. 5); 10—20—26 Å. However, the diameters of the highly organized, partially spherical units are essentially identical with the previously published average values (8—12 Å). In some cases one basic, regular pentagonal polygon in central position was observed, this is surrounded by further similar pentagonal biopolymer units (Plate I, fig. 4, plate II, the framed part of the picture). The diameter and the shape of the holes vary; 25—30 Å, mostly isodiametric, but longer, and larger holes (e. g.: 160 Å) were also observed.

237. — This experiment resulted unusual results, in connection with these it is possible that these ultrastructural elements are not of exine origin but other kind of tissue fragment. On the other hand it is important in methodical respect, that this method is suitable to study the submicroscopic structures of the different space levels of the fragments. On picture 6 of Plate I, the darker superficial, and the light-coloured inner part are well shown. Helical structures were also aberved (Plate I, fig. 7), whereas independent of its doubtful origin we belive that they are important.

238. — This experiment well disclosed the basic biopolymer units, the diameter of the regular pentagonal polygon units are in general 8—12 Å. The highly organized spherical units and their arrangement, and the holes between the biopolymer system are similar to those discussed at experiment No 236 (Plate I, fig. 2, plate II).

239. — On the TEM pictures we have observed microscopical fungi, in this way we keep this experiment not appreciable. But it is noteworthy that in some places the basic-biopolymer units of the sporopollenin are well shown.

250. — Similarly to experiment No 235 resulted in no appreciable data.

251. — At this experiment highly organized spherical units, forming a network were observed. In some places the spherical units may be arranged into filaments.

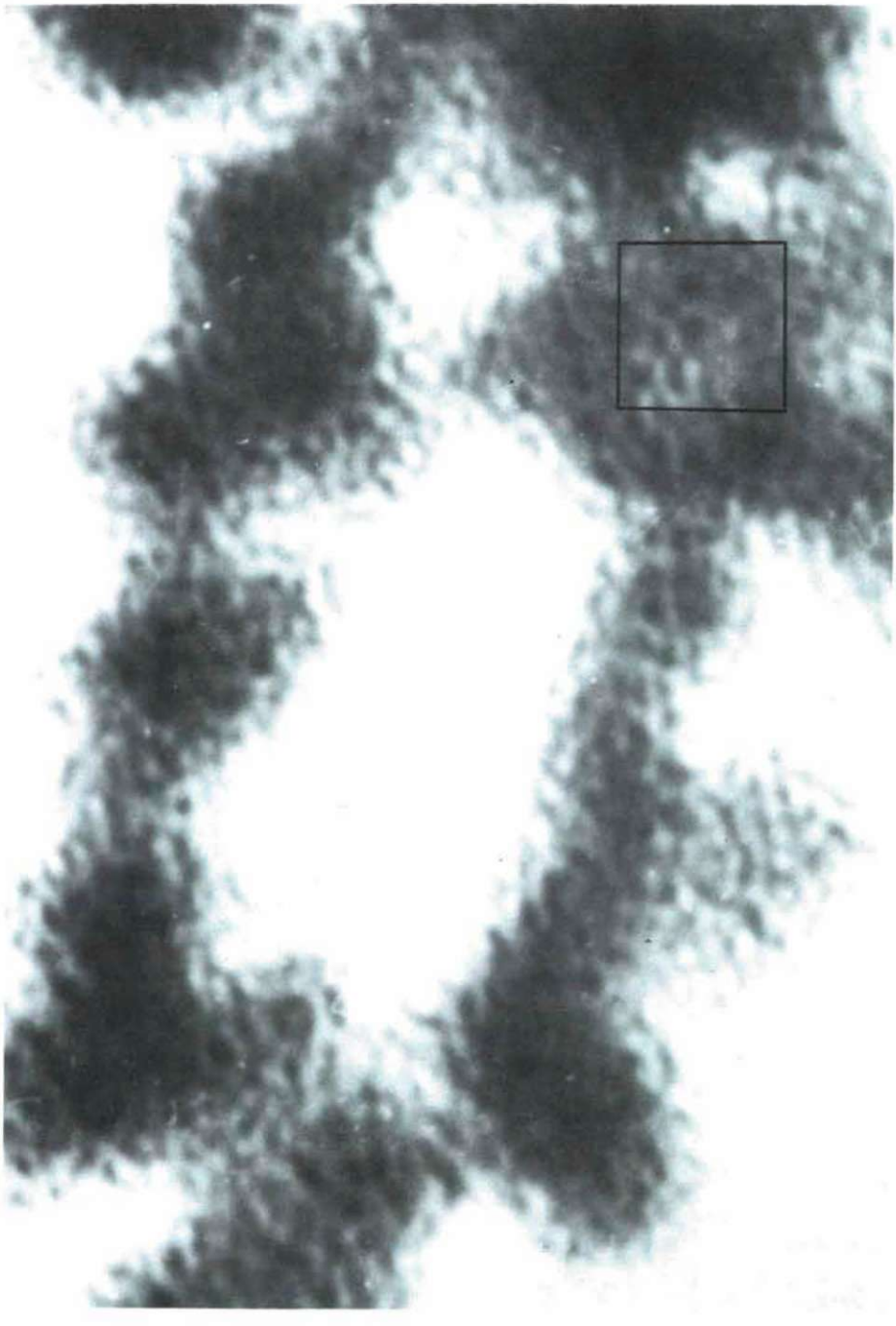
252. — Essentially this experiment gave the same result as at those of No 237 (cf. Plate I, fig. 6).

253. — This experiment resulted in very useful data in the knowledge of the basic biopolymer units of the sporopollenin. In several parts of the TEM pictures we have observed regular pentagonal polygon units and their arrangements too. The modified Markham rotation method was also applied at two biopolymer basic units (Plate IV, fig. 1—4).

Plate II

Alnus glutinosa (L.) GAERTN.

Experiment No 236, the biopolymer organization of the sporoderm is well represented on three levels. The basic biopolymer units are arranged into spherical ones (see the framed part of the picture), and these form also a network, x500000.



254. — This experiment served very appreciable data to the different phases of this kind of method, applied for the first time at this research program. On fig. 2 of Plate V, the different steps of the degradation are well shown until the dissolution. At the last phase the stratification of the exine may not be recognized. On Plate IV, and in picture 1 of Plate V, the morphological characteristic features of the pollen grains of *Alnus* are well shown inside this the biopolymer organization of the sporopollenin, too. The basic biopolymer units may be seen in particular in the tectum, the highly organized ones mostly in the infratectal layer. In the picture of Plate IV, well shown is the dissolution of the exine, and the biopolymer units which emerged into the surrounding medium.

Discussion

The method of the fragmentation, besides the previously used ones, assured new opportunities in the investigation of the biopolymer systems of the partially degraded exines. We need to emphasize that this method completes and not replaces the previously applied ones. We must stress again that in some cases the origin of the biopolymer structures may be doubtful. But this does not diminish the importance of the newly applied method. Resuming, this research direction supports as well the importance of the multidisciplinary investigations.

Plate III

1—4. *Alnus glutinosa* (L.) GAERTN.

1. Experiment, No 253, the regular pentagonal polygons of the basic-biopolymer skeleton are well shown, x500000.

2. Experiment, No 253, detail from the regular pentagonal polygon, basic biopolymer structure, x1 million.

3, 4. Experiment, No 253, the biopolymer structure after the modified Markham rotation, C.P.5.A.5.5., x1 million.

Plate IV

Alnus glutinosa (L.) GAERTN.

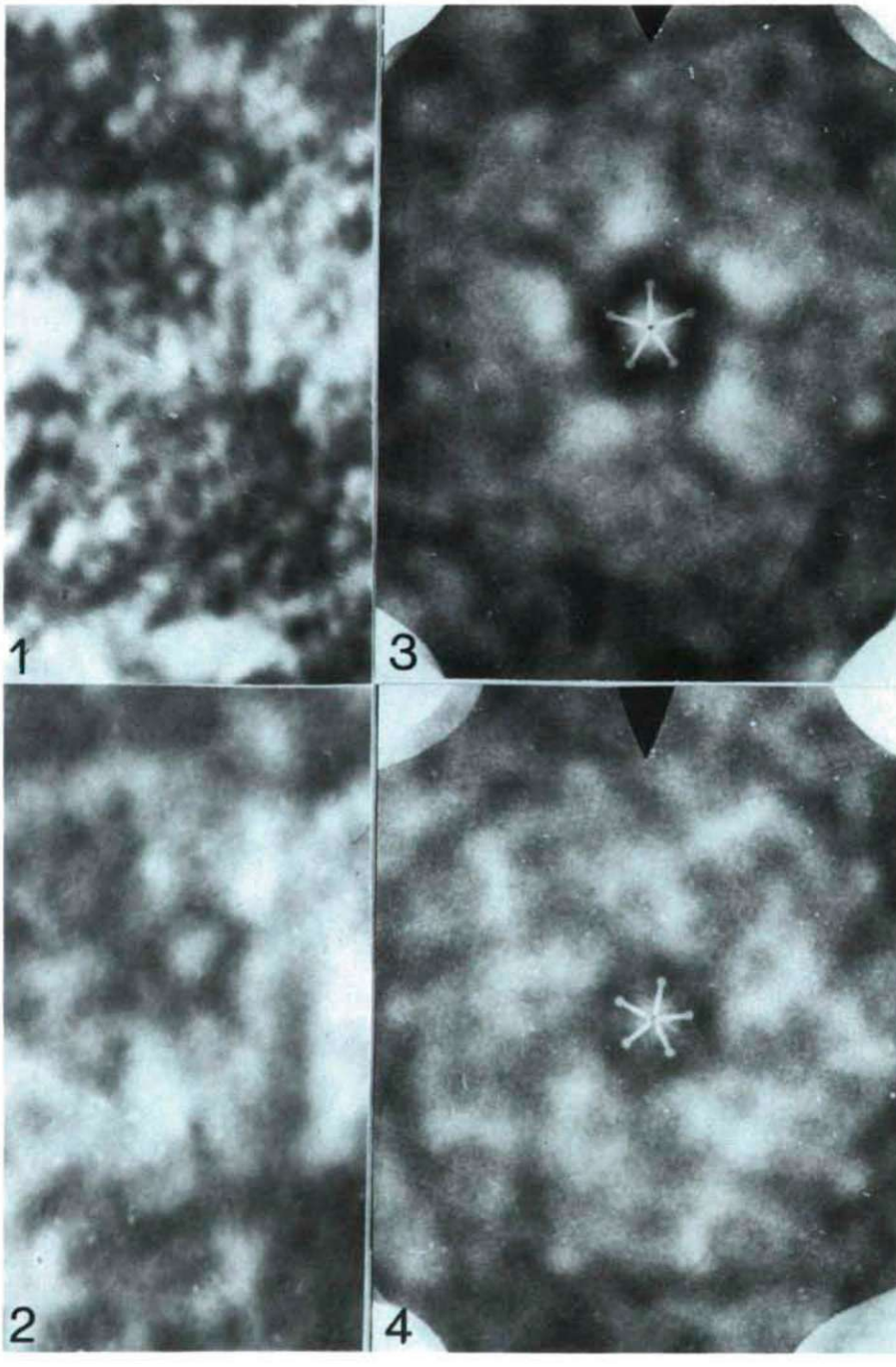
Experiment, No 254, partially degraded exine of the pollen grain, which was originally oriented in equatorial position. The regular pentagonal polygon basic units of the tectum are well shown, the degradation of the surface, and the highly organized biopolymer units of the infratectum, x250000.

Plate V

1—3. *Alnus glutinosa* (L.) GAERTN.

1. Experiment, No 254, detail from the biopolymer organization of the tectum, and the infratectum, x500000.

2, 3. Experiment, No 254, the degrees of fragmentation and partial degradation are well shown, x3600.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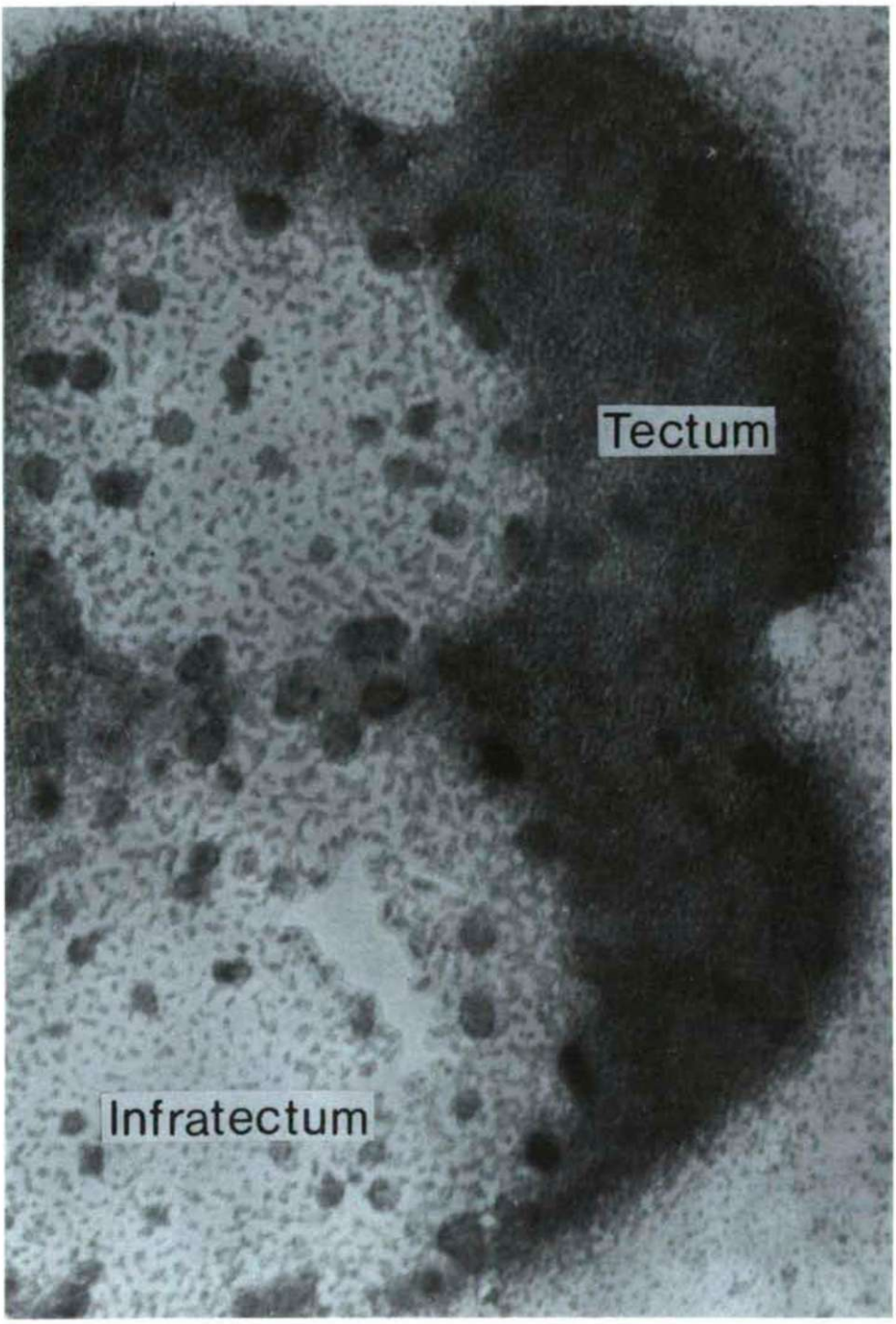
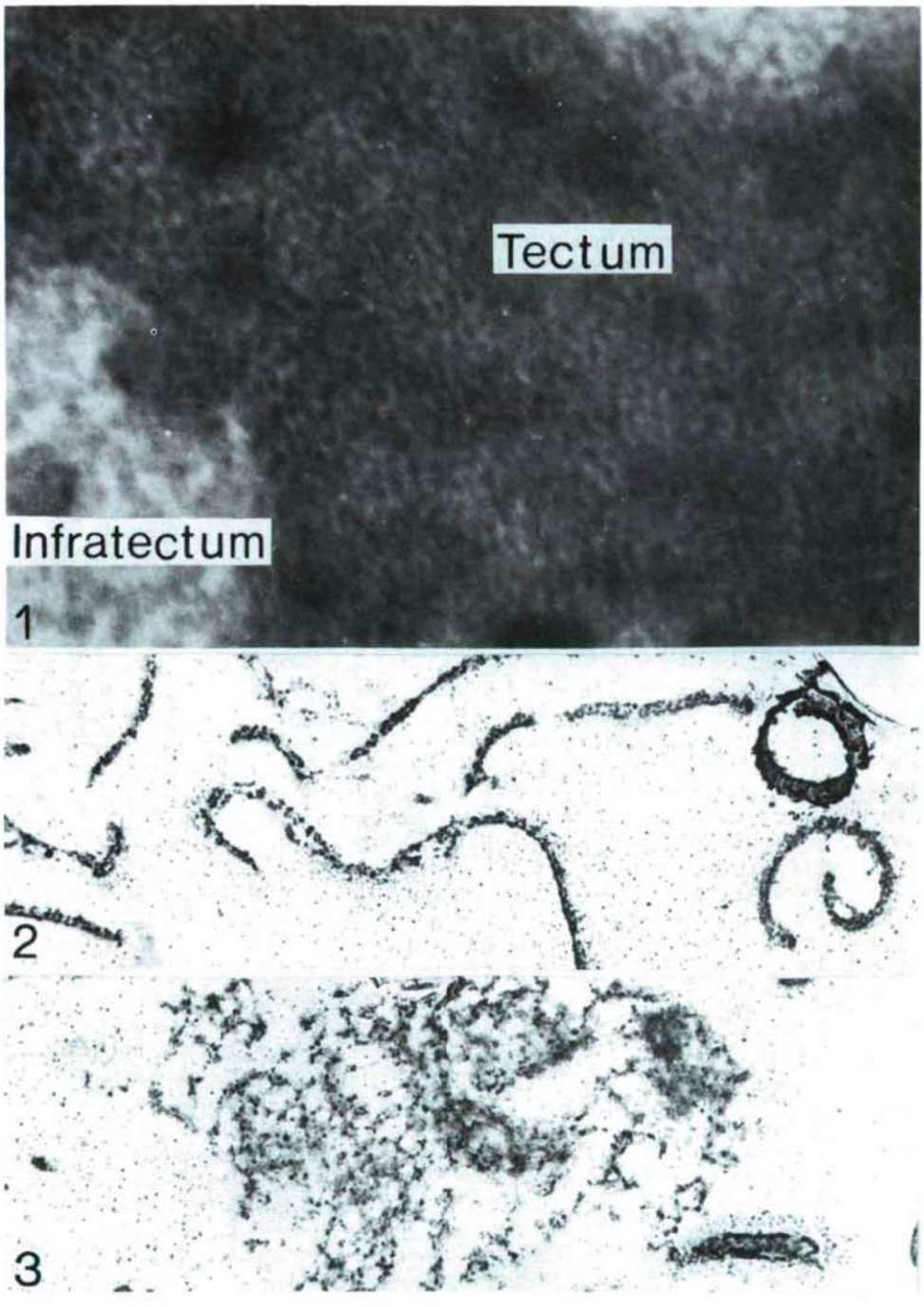

Tectum
Infratectum


Tectum
Infratectum
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Acknowledgements

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DEMONSTRATION OF THE EXTENT OF DROUGHT RESISTANCE IN WINTER WHEAT VARIETIES, AND STUDY OF THE PROLINE ACCUMULATION ABILITY OF 25 CULTIVATED SPECIES

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Abstract

The drought tolerance of bred varieties of one species was found to be directly proportional to the extent of proline accumulation in the isolated leaves. The water deficiency of leaves isolated at flowering time in six wheat varieties was increased up to the lethal level by means of the live-wilting method during exposure to light for 3 days. This means an identical "internal" water deficiency.

The highest proline concentrations were found in "GK Szőke" and "Jubulejnaja 50", i. e. 36% and 33% increases in proline content, respectively. Proline tests were also carried out on the isolated spikes. The lowest proline was found in "GK Őrzse" and the highest proline increase in the same two varieties as found for the leaves. The increase in proline content was higher in the spikes than in the leaves, i. e. 95% and 88%, respectively. There was a heavy drought after flowering during field trials in the study year. Of the five middle-ripening varieties, "GK Szőke" produced the highest yield, as was expected on the basis of the proline tests.

Key words: Free proline, live-wilting, isolated leaves, lethal water deficiency.

Introduction

It is known that the isolated leaves of mesophyte soft-stemmed plants accumulate a huge amount of free proline in response to a severe water deficiency with optimal lighting (DASHEK and HARWOOD, 1974; TYMMS and GAFF, 1979; HUBAC and SILVA, 1980; LEVITT, 1980; PÁLFI and PINTÉR, 1980; PALEG and ASPINALL, 1981; GULYÁS and PÁLFI, 1986). It has also been reported that in the case of drought and an extensive water deficiency of the leaves, the high proline concentration has a protective effect on the plants (BLUM and EBERCON, 1976; DASHEK and HILLS, 1981; SIMINOVITCH and CLOUTIER, 1981; PÁLFI et al., 1983; BISWAS and CHOUDHURI, 1984; JOYCE et al., 1984; VAN SWAAIJ et al., 1985).

It has been concluted from the high proline concentration that those species accumulating more proline under conditions of equal water deficiency display a better drought tolerance. Our results, however, have not supported these findings. Examinations of the water deficiency of isolated leaves and shoots of 14 cultivated species revealed that the drought tolerance of a particular species is not connected

with its proline accumulation ability. This conclusion is supported by the experimental results of WALDER and TEAVE (1974) in soy bean and sorghum, and of PATEL and VORA (1985) in wheat, *Plantago ovata, Papaver somniferum* and *Brassica juncea,* and by the practical results of plant breeding: among the varieties of one species, those have a better drought tolerance which are capable of accumulating proline induced by a gradually increasing water deficiency (PÁLFI at al., 1978, 1983; PÁLFI and GULYÁS, 1986).

Consequently, the proline test can be used to determine the drought tolerance of the varieties of one species. Comparisons of sunflower varieties (SAVINIVASA, 1977), ground nut varieties (SASHIDHAR et al., 1977) and maize varieties (PINTÉR et al., 1979) have shown that the level of proline accumulation connected with the drought tolerance is a heritable trait. This was confirmed by the results of BLUM and EBERCON (1976), MALI and MEHTA (1977), LEVITT (1980) and PALEG and ASPINALL (1981). VAN DE DIJK (1981) found that a given level of "external" water deficiency can cause different levels of "internal" water deficiency, which is actually the main difference between wheat varieties as concerns drought resistance. Accordingly, in determinations of the drought tolerance of different varieties, the "internal" water deficiency of the shoots and leaves must be equal. In the present study, a gradually increasing water deficiency was induced in leaves isolated at flowering time in 6 wheat varieties, with the aim of creating an identical level of "internal" water deficiency. This was followed by determination of the proline content of the water deficient leaves. Proline analysis was also carried out in the spikes of the same varieties following establishment of the constant water deficiency level. The average lenght of the upper two leaves of the shoots was measured and compared with the extent of proline accumulation. In water deficient shoots and isolated leaves of several cultivated varieties, the proline accumulation ability and the free total amino acid content were studied.

Materials and Methods

The 6 wheat varieties used in this study were bred and maintained in the Cereal Research Institute at Szeged. The names of the varieties can be seen in Table 1. Since the water deficiency is most acute at flowering and the following developmental stage in Hungary, the leaves were removed when the first and partly empty anthers appeared in the middle of the ear. This means that samples were taken from each variety at the same developmental stage. The water content of the soil was still optimal at flowering, since 45 mm of precipitation had fallen during the previous 4 weeks. In order to provoke a water deficiency, the two upper leaves of the 24 shoots of each variety were cut off.

The average lenght of the leaves were measured, and the leaves were then laid out in two groups in each variety separately. The groups of leaves were fixed adhesive tape on a plate covered by filter paper. The live-wilting was carried out under the following conditions; 26—28 °C air temperature, with 90% relative humidity for 60 hours and with 5000 lux lighting (in a phytotron chamber). During the last 12 hours of the live-wilting, the humidity was reduced to 60% in order to ensure the lethal water deficiency. The induction of water deficiency during 3 days is called live-wilting. This provoked water deficiency ensures that the levels of "internal" water deficiency of the varieties are equal.

Following live-wilting, the leaves were cut into small pieces, dried at 90 °C and then ground to powder. The leaf powder was dried further at 105 °C, and finally sealed hermetically in bottles.

The spikes of the same shoot were also cut off, subjected to the artifical live-wilting procedure for 3 days, then dried and ground prior to determination of the proline content. The lethal water deficiency provoked by the new method of live-wilting of the isolated leaves, living for at least 60 hours, led to the accumulation of a high proline concentration. The proline content of the leaves varied with the varieties. Those varieties capable of accumulating more proline at a given water deficiency level have a better drought resistance (SINGH et al., 1972; BRITIKOV, 1975; BLUM and EBERCON, 1976; MALI and MEHTA, 1977; SRINIVASA, 1977; LEVITT, 1980).

The proline analysis of the leaf powder was carried out according to Paleg and Aspinall (1981) and the total amino acid content was measured according to Rosen (1957).

Results and Discussion

The shoots separated from the root system and the isolated leaves lost a considerable amount of water immediately after the cutting and within the next 24 hours (if the vapour content of the air was saturated). Following this, the leaves became self regulated, resulting in an increase in the proline accumulation which slowed down further loss of water. The accumulated proline contents of the isolated leaves of wheat varieties provoked by live-wilting can be seen in Table 1.

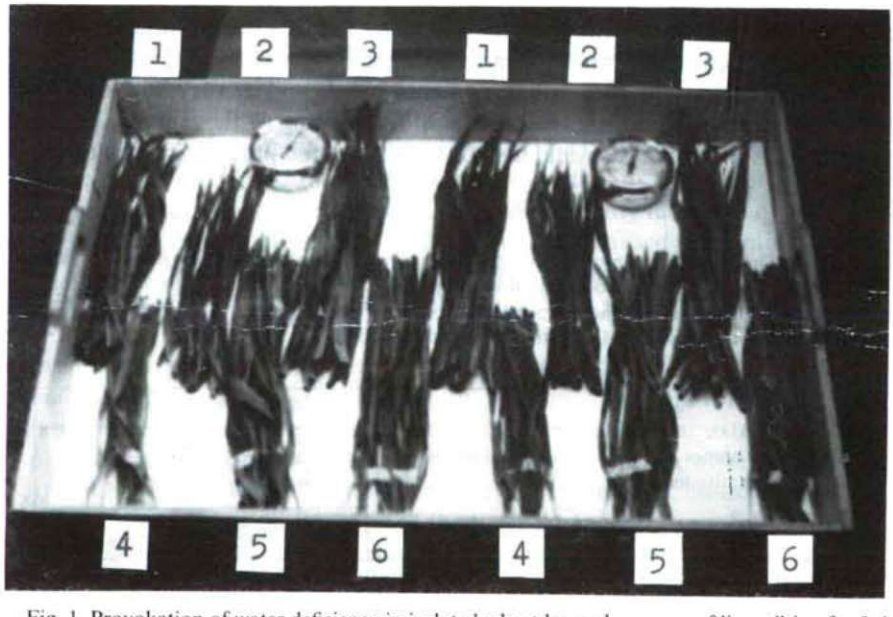

Fig. 1. Provokation of water deficiency in isolated wheat leaves by means of live-wilting for 3 days. 40 isolated leaves were laid out and fixed in two groups for each of the 6 varieties in order to ensure even lighting. The light intensity was 5000 lux, the air temperature was 26—28 °C, and the relative humidity of the air during the first two and a half days was 90%, and during the last 12 hours was 65%.

Varieties:

1 = Bucsányi 20 2 = GK István 3 = GK Szöke 4= Jubilejnaja 50 5 = GK Bence 6 = GK Őrzse

Table 1 shows that the isolated leaves accumulated different amounts of proline as a result of live-wilting or lethal water deficiency. The proline contents of two wheat varieties were outstanding: "GK Szőke" and "Jubilejnaja 50", with 3,17% and 3,10% total proline content, respectively. This means a 36% and 33% increase in proline content, respectively relative to the lowest level, in "GK Őrzse". The proline contents of "Bucsányi 20" and "GK István" increased by 9,4% and 12,9%, respectively.

The application of live-wilting to provoke the lethal water deficiency of isolated leaves may solve the debate between those who elaborated the proline test and have successfully used it (SINGH et al., 1972; BLUM and EBERCON, 1976; MALI and MEHTA, 1977; PALEG and ASPINALL, 1981; SIMINOVITCH and CLOUTIER, 1981; VAN DE DIJK, 1981; VAN SVAAIJ et al., 1985), and those who are against it (GUPTA and SHEOVAN, 1979; HANSON et al., 1977, 1979; ILAHI and DÖRFFLING, 1982).

The latter group induced a constant "external" water deficiency level, but the "internal" water deficiency level was different in the living leaves (this is the point when the varieties differ from each other in drought tolerance).

The presented live-wilting method ensures that the leaf samples taken at flowering time have a constant "internal" water deficiency level, which is the lethal level. The data in Table 1 suggest that the varieties with medium leaf lenght are advantageous from the aspect of resistance.

The accumulated proline contents of isolated spikes in response to live-wilting or lethal water deficiency can be seen in Table 2.

Table 2 shows that the proline contents in the spikes vary with the varieties more significantly than during the process of live-wilting of the leaves, ranging from 0,61% to 1,19% proline. It should also be noted that the proline accumulation of the

Table 1. The concentration of synthesized proline resulting from live-wilting for 3 days and lethal water deficiency of wheat leaves isolated at flowering time. The concentration of proline is expressed as a percentage of the dry material. The average lenght of the upper two leaves is also reported. The proline content is also given as a percentage of the lowest proline content.

The names of wheatstrains	Length of leaf in cm	Concentration of proline	
		Dry substance	Minimal proline
		in per cent	
1. Bucsányi 20	29	2.55	109.4
2. GK István	27	2.63	112.9
3. GK Szőke	29	3.17	136.1
4. Jubilejnaja 50	27	3.10	133.0
5. GK Bence	30	2.46	106.0
6. GK Őrzse	30	2.33	100.0

Table 2. Accumulated proline concentration of live-wilted leaves as a result of a lethal water deficiency. The live-wilting was carried out for 3 days at flowering time.

The names of wheatstrains	Concentration of proline	
	Dry substance	Minimal proline
	in per cent	
1. Bucsányi 20	0.94	154.1
2. GK István	0.65	106.5
3. GK Szőke	1.15	188.5
4. Jubilejnaja 50	1.19	195.1
5. GK Bence	0.86	141.0
6. GK Őrzse	0.61	100.0

leaves is 3—4 times higher than that of the spikes. When the proline contents in the spikes of the varieties were compared, the lowest one and the two highest turned out to be the same as in the leaves. The lowest proline level was detected in "GK Őrzse" (100%), while "GK Szőke" and "Jubilejnaja 50" showed the highest increases in proline: 188% and 195%, respectively.

The drought resistance data obtained by using the live-wilting of isolated leaves were supported by the practical results. HARMATY (1988) carried out field trials in the same year in lime meadow soil and on sandy soil with bad water management.

Because of the lack of precipitation and the high daily temperature (35—40 °C), a drought followed the flowering. This hot weather caused the grains to become stunted and the yield decreased. On both types of soil, from the middle-ripening group "GK Szőke" produced the highest yield. This variety was found to be the most drought-resistant at flowering time in our trials too. "Jubilejnaja 50" displayed considerable drought resistance and was the fifth out of 10 in yield production in meadow soil, and the third out of 12 in sandy soil. It is known that this standard variety is capable of producing an average yield under extreme conditions. The proline accumulation capacities of different species ar shown in Table 3.

It can be seen in Table 3 that the 25 species examined in this experiment can be devided into two groups on the basis of the proline concentration. In the first group, the proline accumulation in the leaves is extremely high, between 1,0% and 4%. In the second group, the proline remains well under 1,0%, although in these species the proline content also increased by 300—500% as compared with the control supplied with adequate water (PÁLFI et al., 1983).

It should be noted that we have studied the proline concentrations of isolated leaves of varieties storing proline in smaller quantity for 20 years (PÁLFI, 1968; PÁLFI et al., 1974, 1975, 1978, etc.). These results strongly support the data in Table

Table 3. Proline accumulation ability of various species, resulting from the lethal water deficiency of the isolated leaves. As a result of live-wilting for 3 days, the proline and total amino acid concentrations increased in mono- and dicotyledonous species belonging in one family (the species are separated by lines within the families). The samples were taken at flowering time. The live-wilting was carried out with the whole isolated shoot in the case of species with small leaves, such as *Medicago* and *Trifolium*. The concentrations are given as percentages of the dry material.

Species	Proline	Total amino acid
	concentration, per cent	
Dicotyledon		
Medicago sativa	3.64	9.12
Trifolium repens	2.37	8.25
Pisum sativum	1.82	8.76
Lens culinaris	1.53	6.34
Phaseolus vulgaris	0.56	6.87
Solanum tuberosum	1.81	7.23
S. lycopersicum	1.64	7.82
Capsicum annuum	2.89	9.16
Nicotiana tabacum	2.57	8.06
Brassica oleracea	3.88	10.64
B. napus	2.42	8.25
Raphanus sativus	1.63	7.27
Cucurbita pepo	0.38	6.56
C. maxima	0.45	6.43
Cucumis sativus	0.42	6.89
C. melo	0.36	6.74
Helianthus annuus	1.67	7.23
Lactuca sativa	0.35	7.08
Spinacea oleracea	0.46	8.12
Beta vulgaris	0.38	7.25
Monocotyledon		
Triticum aestivum	3.14	10.16
Hordeum vulgare	2.28	8.06
Secale cereale	1.93	8.78
Zea mays	0.42	9.34
Sorgum vulgare	0.51	9.27

3, showing that these species really have a low proline accumulation ability (well under 1,0%).

The mono- and dicotyledonous 25 species belong in 7 families. It can be seen that species having an extremely high or low proline accumulation ability can belong in one family. Consequently, the proline accumulation ability induced by the lethal water deficiency of the isolated leaves is not characteristic for certain families. Although general consequences can not be drawn from these results, they can serve as a good basis for further studies of proline synthesis and oxidation and the enzymes taking part in these processes.

Table 3 shows that the total amino acid contents of the species are high, varying between 6% and 11%. This suggests that the lethal water deficiency substantially increases not only the concentration of proline, but also those of other amino acids. At optimal water supply, the total amino acid content usually varies between 1,0% and 2,0%. It should also be considered that the proline concentration induced by the dry soil in intact plants grown in the field is substantially lower (by about 0,3—0,5%) than that of the isolated leaves (PÁLFI et al., 1974, 1975, 1978).

The water supply in the isolated leaves is cut off, while in the intact plants, even in the case of an extreme drought, the roots penetrating deeply into the soil supply the plant with a moderate amount of water. This is why a lethal water deficiency very rarely occurs in crop plants, though the yield can be seriously decreased by drought. The present proline data and the results of the proline test relate exclusively to isolated leaves. This is in good agreement with other studies which used isolated leaves or segments of leaves of plants grown in culture dishes (SINGH et al., 1972; BLUM and EBERCON, 1976; MALI and MEHTA, 1977; GUPTA and SHEOVAN, 1979; HANSON et al., 1979; SIMINOVITCH and CLOUTIER, 1981; THAKUR et al., 1988; etc).

These authors have already reported on the role and advantages of proline as compared with other amino acids regarding drought resistance. We have also described this in detail (PÁLFI et al., 1975, 1975, 1983).

It should also be taken into consideration that the proline accumulation ability is an evolutionary, heritable trait (BLUM and EBERCON, 1976; LEVITT, 1980; PALEG and ASPINALL, 1981; VAN SWAAIJ et al., 1985). This trait of a particular species or bred variety could presumably be transferred by means of traditional crossing or genetic manipulation to other high-yielding varieties which do not have sufficient drought resistance (WYN JONES and CORHAM, 1986). Throught the crossing of related inbred maize lines, this has already been carried out successfully in part (PINTÉR et al., 1981).

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COMPARISON OF PHOTOSYNTHETIC PERFORMANCES IN TWO GENOTYPES OF BEAN DEEPOXIDATING VIOLAXANTHIN QUICKLY AS WELL AS SLOWLY

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Abstract

Differences were studied in the performance (the dry matter production in connection with CO2 assimilation, leaf area, ratio of photosynthetizing tissues, malate, sucrose, starch contents of the leaf) between the XQ and XS genotypes (deepoxidating violaxanthin quickly (XQ) as well as slowly (XS) during the induction period of photosynthesis) of the C3 type bean. We observed the differences of the acclimation of the plants were grown at 3 light regimes: medium light (ML): 200 $\mu mol.m^{-2}.s^{-1}$ photosynthetic photon flux density (PPFD) and 16 h — 8 h light dark period (LDP); low light (LL): 100 $\mu mol.m^{-2}.s^{-1}$ PPFD and 16 h — 8 h LDP; short light (SL): 200 $\mu mol.m^{-2}.s^{-1}$ PPFD and 30 min — 15 min LDP.

Dry matter reducing effect of the LL and the SL treatments seemed to be in connection with the low CO2 assimilation rate measured at the PPFD where the plants were grown and with the low quantum yield. Within a genotype the higher sucrose and the lower starch proportion on the effect of light treatments may be in connection with the higher shoot and lower root ratios. Comparing the XQ and XS genotypes of bean, we found that the malate, sucrose levels are lower and the starch level is higher in the leaves of the XQ than those of the XS genotypes.

The quantum yield may be in positive correlation with chlorophyll a + b content and negative correlation with the light compensation point.

Key words: genotype, CO_2 assimilation, biomass, violaxanthin, sucrose, starch, malate

Introduction

The differences in the performance of genotypes may be in close connection with the photosynthetic pathways. For instance such differences are shown by the variation found between the photosynthetic pathways of the C3 and C4 species of *Panicum* genus (DOWNTON, 1975) and between the genotypes of *Zea mays* deepoxidating violaxanthin quickly (XQ) as well as slowly (XS) during the induction period of photosynthesis (MARÓTI, 1986). Our aim was to study the differences in the performance (the dry matter production being in connection with CO_2 assimilation, leaf area, ratio of photosynthetizing tissues, malate, sucrose, starch content of the leaf) between the XQ and the XS genotypes of the C3 type bean. We observed the differences in the acclimation of the plants grown at medium and low photosynthetic photon flux densities and short light dark period.

The carboxylating step is well characterized by the slope of the initial part of the curve of CO_2 assimilation rate versus incident photosynthetic photon flux density. This initial slope of the curve is the incident quantum yield that is lower in the C3 plants (0.052 mol CO_2.mol^{-1} photon) than in C4—NADP—ME plants (0.065 mol CO_2.mol^{-1} photon) (EHLERINGER and PEARCY, 1983). Since the optimal electron transport needs equilibrium between production and consumption of the reduction power (NADPH) in the chloroplast, therefore the export of the reduction power in the form of malate plays an important role in the acclimation to the changing conditions (SCHEIBE et al. 1986). On the one hand, the photosynthetic malate is the precursor of the tricarboxylic acid cycle in the mitochondrium, because the amino acids of the tricarboxylic acid cycle are synthetized from the photosynthetic CO_2 fixation (KENT, 1979). On the other hand, the malate exported from the chloroplast carries the reduction power to the peroxisomes (TOLBERT, 1979), and to the cytoplasm. The increase of the CO_2 concentration rises the malate level and reduces the nitrate level since the malate oxidation is the main NADH source for the cytoplasmatic nitrate reduction (NEYRA and HAGMAN, 1976; MARIGO et al., 1985). Certain plants can store malate in inverse quantity as nitrate in their vacuoles (GERHARDT AND HELDT, 1984; MARIGO et al., 1985).

The rate of the sucrose synthesis is in close correlation with the rate of CO_2 assimilation through the fructose-2,6-bisphosphate regulation system (STITT et al., 1987). The vacuoles of the mesophyllum cells are temporary pools of sucrose in light if sucrose productivity surpasses the uptake capacity of phloem (KAISER and HEBER, 1984). The excess sucrose synthesis gives a signal for the fructose-2,6-bisphosphate regulating system to start the starch synthesis (PREISS, 1986).

The starch content of the leaves is in inverse ratio to the daily photosynthetic period (CHATTERTON and SILVIUS, 1979).

Genotype pairs was found in some plant species (maize, bean, sunflower) on the basis of the leaf anatomy, chloroplast ultrastructure and physiological light acclimation. The rate of the deepoxidation of violaxanthin (i. e. the rate of developing of protongradient in thylakoids) quicker, the rate of quenching of chlorophyll-a fluorescence in the M—T period (i. e. the start of the non-cyclic electrontransport) and the rate of oxygen evolution is slower in the XQ genotypes in the XS genotypes (PATAKY and MARÓTI, 1985; WALKER, 1985; MARÓTI, 1986) during the induction period of photosynthesis. The XQ genotypes have lower dry matter, leaf thickness and growth rate, higher water content than the XS genotypes have (MARÓTI and MARGÓCZI, 1984; MARGÓCZI and MARÓTI, 1985). The quantity of appressed membrance in the chloroplasts of the XQ genotypes is greater, the number of grana, the sizes of the loculi are less than in the XS genotypes (PATAKY and MARÓTI, 1985; MARÓTI, 1986).

Materials and Methods

The comparison of the photosynthetic performances was carried out on the XQ and the XS genotypes of bean (*Phaseolus vulgaris* L. 'Cherokee').

The bean plants were grown for 40 days in 600 cm^3 plastic pots in the mixture of sand-perlit (I:I) in phytotron with 330 $\mu mol.mol^{-1}$, CO_2 content 8.4 $\mu mol.mol^{-1}$, saturation deficit of water vapour in the air, and with a temperature of 23 C.

The three light treatments were: medium light (ML): 200 $\mu mol.m^{-2}.s^{-1}$ photosynthetic photon flux density (PPFD) and 16 h — 8 h light dark period (LDP); low light (LL): 100 $\mu mol.m^{-2}.s^{-1}$ PPFD and 16 h — 8 h LDP; short light dark period (SL): 200 $\mu mol.m^{-2}.s^{-1}$ PPFD and 30 min — 15 min LDP. The light sources were fluorescent tubes (Tungsram F 33 types).

The ML and the LL plants were kept in darkness for 8 hours and the SL plants were kept in darkness for 30 minutes then their developed 1. trifoliate leaves were cut off. The isolated leaves were illuminated with 800 $\mu mol.m^{-2}.s^{-1}$ PPFD light in humid 26 C air containing 340 $\mu mol.mol$ CO2 for 30 minutes, then they were fixed in liquid air and lyophilized. The malate (HOHORST, 1970), the sucrose and the starch content (HANDEL, 1968; DUBOIS et al., 1956) were determined. We measured the change of the rate of CO_2 assimilation with infrared gas analyser (VEB Junkalor: Infralyt 5). The calculations (CO_2 assimilation rate, incident quantum yield, light compensation point) were carried out after LONG and HALLGREEN, (1985); JANAC et al. (1971); CAEMMERER and FARQUHAR, (1981).

From the leaves we took samples for lyophilization, we made chlorophyll analysis (FRENCH, 1960) and determined the ratio of the photosynthetic tissues after fixing with glutaraldehyde (KARNOVSKY, 1965), imbedding in paraffin, making 16 μm thick cross-sections.

Results

DRY MASS AND THE DRY MASS PROPORTION OF ORGANS (FIGS. 1., 2.)

Dry mass of the total plant, the roots, the stem and the leaves decrease more intensively in the LL plants than in the SL plants comparing to the ML plants. The mass proportion of the roots is lower in the LL and similar in the SL plants compared to the in the ML plants. LL and the SL treatments increase the mass proportion of the stem comparing to the ML.

Dry mass of the total plant and leaves in the XQ is higher than in the XS genotypes at each treatments.

LEAF AREA (FIG. 3.)

In the plants grown at the LL and the SL the leaf area is higher than in the plants grown at the ML.

There are no significant differences between the leaf area of the two genotypes.

SPECIFIC LEAF MASS (FIG. 3.)

The specific leaf mass of the LL and the SL plants is lower in both genotype. The specific leaf mass of the XQ genotype is slightly higher than that of XS one at the ML.

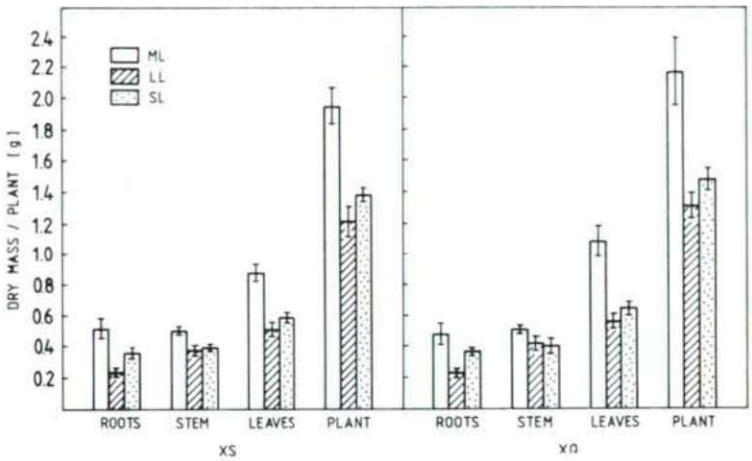

Fig. 1. Dry mass of the organs and the whole plant of the XS as well as the XQ bean genotypes grown at the ML, LL and SL light regimes.

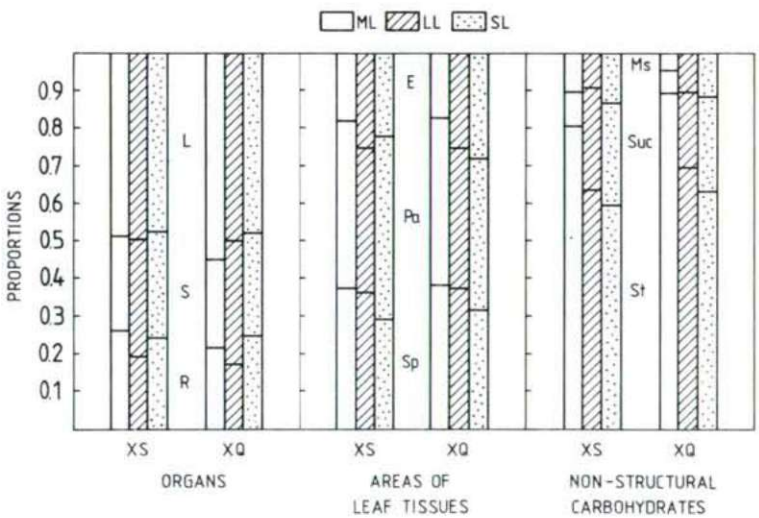

Fig. 2. Dry mass ratios of organs (L: leaves, S: stem, R: roots), proportions of tissue areas in leaf cross-sections (E: epidermis, Pa: palisade parenchyma, Sp: spongy parenchyma) and proportions of the non-structural carbohydrates (MS: monosaccharides, Suc: sucrose, St: starch) in the XS as well as the XQ genotypes of bean grown at the ML, LL and SL light regimes.

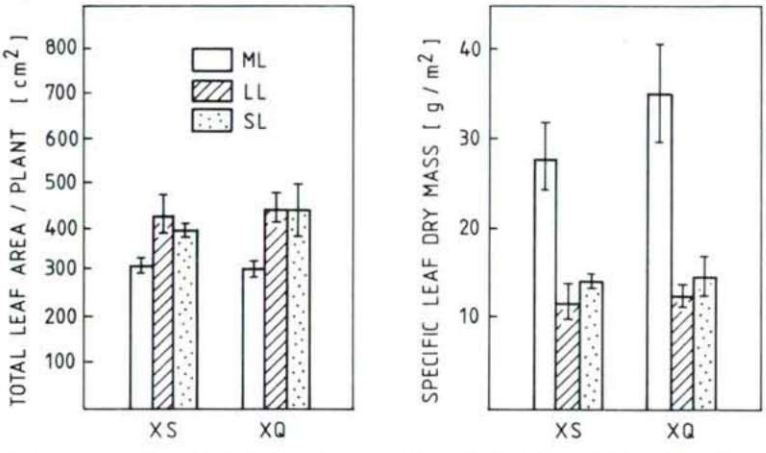

Fig. 3. Leaf area and specific leaf dry mass of the XS as well as the XQ genotypes of bean grown at the ML, LL and SL light regimes.

PROPORTION OF TISSUES IN LEAF CROSS-SECTION (FIG. 2., TABLE 1.)

In the LL plants the proportion of palisade, in the SL plants the proportion of spongy parenchymas are reduced comparing to the ML plants. Differences cannot be observed between genotypes with the exception of palisade parenchyma proportion of the SL plants where this proportion is less in the XQ than in the XS genotypes.

CO_2 assimilation rate after 60 minutes of illumination at the PPFD under the plants were grown, incident quantum yield and light compensation point (Fig. 4.)

In the LL and SL plants the CO_2 assimilation rates are lower than in the ML plants. The CO_2 assimilation rate of the XQ genotype is significantly higher than that of the XS genotype with the exception of the SL treatment.

The quantum yield of the LL and the SL plants is lower than that of the ML plants. Advantage of the XQ could be shown only in the LL light regime.

The light compensation point of the SL plants is outstandingly high, but significant genotypical differences could not be observed in either light treatment.

LEAF TRANSMITTANCE (FIG. 5.)

The leaf transmittance increases slightly in the LL and strongly in the SL plants comparing to the ML plants. There are not any differences between the genotypes.

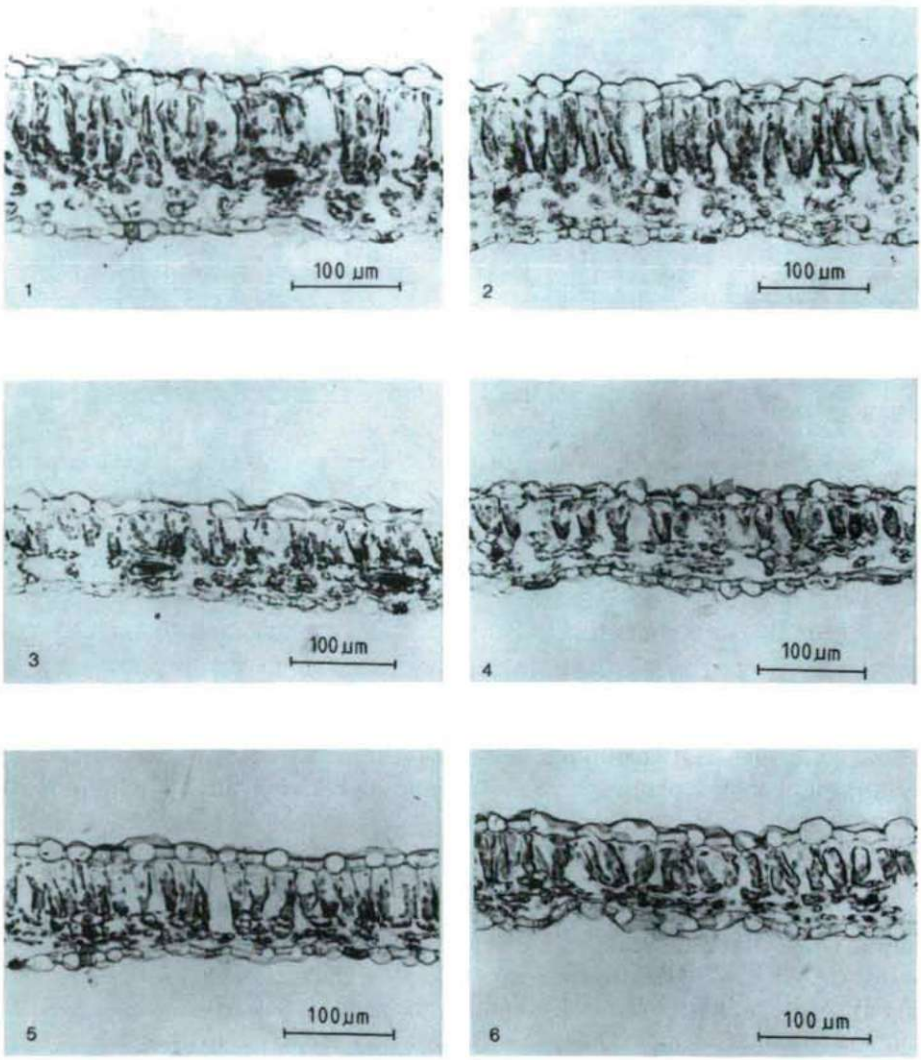

Table 1. Cross-section from 1. trifoliate leaves of the XS and the XQ genotypes of bean grown at the ML, LL and SL light regimes.

1. XS genotype grown at ML 2. XQ genotype grown at ML 3. XS genotype grown at LL 4. XQ genotype grown at LL 5. XS genotype grown at SL 6. XQ genotype grown at SL

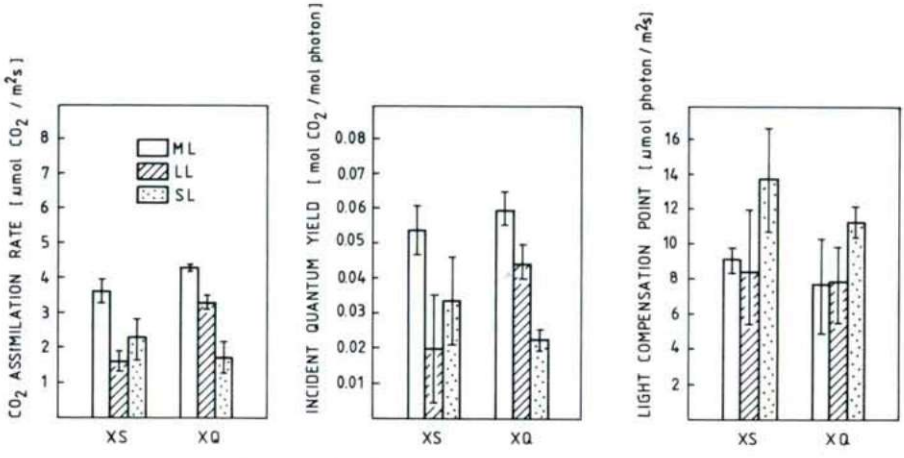

Fig. 4. CO_2 assimilation rate, incident quantum yield and light compensation point of the 1. trifoliate leaves of the XS as well as teh XQ genotypes of bean grown at the ML, LL, and SL light regimes.

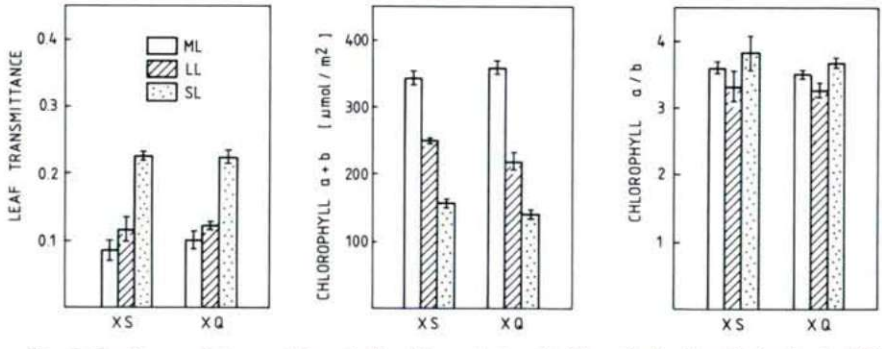

Fig. 5. Leaf transmittance, chlorophyll a + b content and chlorophyll a/b ratio in the 1. trifoliate leaves of the XS as well as the XQ genotypes of bean grown at the ML, LL and SL light regimes.

QUANTITY OF CHLOROPHYLLS (FIG. 5.)

The chlorophyll a/b decreases in plants grown at the LL and increases in plants grown at the SL comparing to ML. There are not any differences between genotypes. The chlorophyll a + b is lower in the LL and the SL plants than in the ML plants. The chlorophyll a + b is also lower in the XQ than in the XS genotypes except for the plants grown at the ML.

MALATE, SUCROSE AND STARCH CONTENT OF THE LEAVES IN THE 30TH MINUTE OF THE ILLUMINATION (FIGS. 2., 6.)

The malate level is higher in the leaves of the LL and SL plants than in those of the ML plants. The malate content of the XQ genotype is higher than that of the XS genotype, exept plants grown at the LL light regime.

The sucrose content is higher in the LL and the SL plants than in the ML plants of the XQ genotype, but sucrose content of the XS genotype is similar in each light regimes. The sucrose proportion within the non-structural carbohydrates significantly greater in the LL and the SL plants comparing to the ML plants. The sucrose content of the XQ is lower rhan that of the XS genotype only in the ML plants. The sucrose proportion is also lower in the XQ than in the XS genotype but at each light treatments (Fig. 2.).

Starch level of the leaves is significantly lower in the LL and the SL plants than in the ML plants. The starch content and the starch proportion (Fig. 2.) of the XQ genotype are higher than those of the XS genotype.

Discussion

The photosynthetic performance of the plant expresses the efficiency of light conversion to biomass (result of photosynthesis, respiration, photorespiration). The performance could be estimated on the basis of dry matter production in connection with CO_2 assimilation rate, leaf area, ratio of the photosynthetic leaf tissues, and malate sucrose and starch contents of the leaf, respectively.

The stacking degree of the chloroplast membrane system increases in the LL plants (LICHTENTHALER et al., 1981) and decreases in the SL plants (PATAKY and

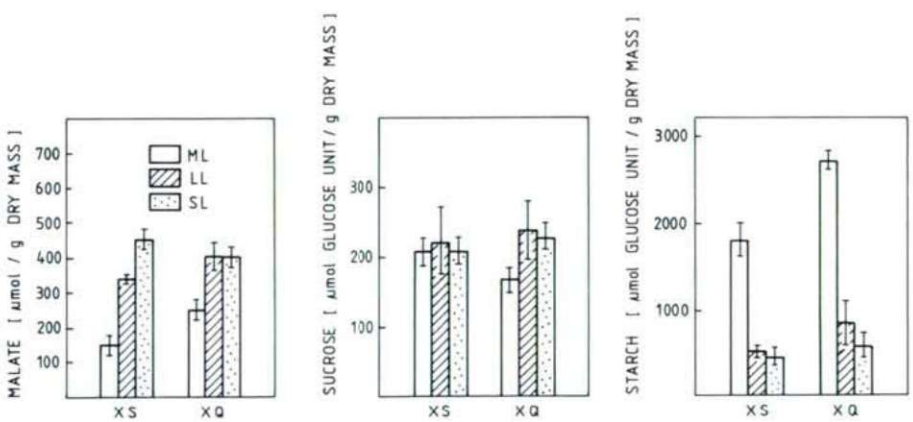

Fig. 6. Malate, sucrose and starch levels in the 1. trifoliate leaves of the XQ as well as the XS genotypes of bean grown at the ML, LL and SL light regimes.

MARÓTI, 1985), but in spite of these facts both light treatments result in a dry mass reduction of bean plants comparing to the ML treatment. The smaller dry matter decrease of the XQ genotype grown at the SL is due to its better light acclimation. The root reducing effect of the LL is consistent with former observations (BJÖRKMAN, 1981) and this is a typical trait of shade acclimation. The LL and the SL treatments result in a phenomenon like shade acclimation: increase of leaf area and reduction of specific leaf mass. The ratios of leaf tissues in cross-section show characteristic differences: in the LL plant the ratio of palisade (cf. LICHTENTHALER et al., 1981), in the SL plants the proportion spongy (cf. MARÓTI and MARGÓCZI, 1984) parenchymas are reduced (Fig. 2.). Dry matter reducing effects of the LL and the SL light regimes may be caused by the reduced CO_2 assimilation rate and quantum yield comparing to the effect of ML light regimes. There is an important difference between the LL and the SL: the light compensation point is unchanged at the LL, but rises at the SL comparing to the ML treatment (Fig. 4.). The latter rise might be due to the weakly developed light harvesting complexes (MARÓTI and TAKÁCS, 1983), which is supported by the small quantity of chlorophyll a + b found in the leaves. The chlorophyll a/b reduction at the LL as well as rise at the SL are consistent with former observations (LICHTENTHALER et al., 1981; MARÓTI, 1982). There may be positive correlation between the incident quantum yield and chlorophyll a + b content as well as negative correlation between the incident quantum yield and light compensation point.

Malate transports reduction power into the cytoplasm for nitrate reduction (MARIGO et al., 1985), into the peroxisomes for glycollate pathway and functions as a carbon source for the anaplerotic operation of the tricarboxylic acid cycle (KENT, 1979). The LL and the SL treatments may reduce the malate level in the cytoplasm which is contrast with other observations (cf. LICHTENTHALER et al., 1981). The rise of sucrose proportion and decline of starch proportion within non-structural carbohydrates in plants grown at the LL and the SL light regimes show the increased transport mobility between chloroplast and cytoplasm in the mesophyll of the leaf of bean plants.

We can establish on metabolite levels of the C3 bean leaves, that the effect of the SL resembles that of the LL treatment.

The lower malate content may be due to the enhanced utilization of malate in the perxisomatic glycollate pathway, in the mitochondrial anaplerotic processes and in the cytoplasmic nitrate reduction. It may be in connection with the higher dry matter of these plants.

The decline of sucrose proportion and the rise of starch proportion within non-structural carbohydrates in the XQ genotype comparing to the XS genotype (Fig. 2.) show the decreased photosynthate transport from the chloroplasts (HUBER, 1984) and result in an increase in its leaf dry mass (Fig. 1.). Within a genotype the higher sucrose and the lower starch ratio on the effect of light treatments may be in connection with the higher shoot as well as lower root ratios.

Comparing the XQ and XL genotypes of bean with those of maize (TÉCSI, 1987) we found that the malate, sucrose levels are lower and the starch level is higher in the leaves of the XQ than those of the XS genotypes.

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MORPHOLOGICAL ELEMENTS OF CONTROL OF SMOOTH MUSCLE ACTIVITY IN THE FROG STOMACH: AN EM STUDY

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Abstract

The elements of the myenteric plexus, the interstitial cells of Cajal and the entero-endocrine cells of the frog stomach were studied with a transmission electron microscope. The profiles of the plexus and the fine structural features of the neuromuscular junction were described. The interstitial cells were identified at the ultrastructural level: a small amount of smooth endoplasmatic reticulum was observed in their cytoplasm. A few entero-endocrine cells were found in the epithelial layer. Their ultrastructure was similar to that in other vertebrates. The possible action of these elements on the contraction of the musculature suggests a multifunctional influencing of peristalsis: namely (1) a direct action of the nerves on the muscles; (2) changes in the pacemaking activity of the interstitial cells; (3) local systemic action of serotonin and peptides from entero-andocrine cells on the musculature.
Key words: frog stomach-myenteric plexus- interstitial cellsentero-endocrine cells-ultrastructure.

Introduction

Since the first reports on the innervation of the frog alimentary canal (BOTAZZI, 1899; CAJAL, 1902; DIXON, 1902; GAUPP, 1899) a considerable number of papers have dealt with this topic (e. g. BOYD et al., 1964; CAMPBELL, 1969; COLE, 1926; GUNN, 1951; HIRT, 1934; RASHID, 1972; READ and BURNSTOCK, 1968, 1969; YÜH, 1931). ANDERSON and CAMPBELL (1984) provided evidence of the presence of serotonin in the neurons of *Bufo* gut. As regards the frog stomach innervation, only classical morphological data are available (CAJAL, 1902; COLE, 1926; DIXON, 1902; GUNN, 1951; WONG et al., 1971). The gross morphology of the myenteric plexus of the frog stomach was recently described (GÁBRIEL et al., 1987) established by means of NADH-diaphorase histochemistry. However, the electron microscopic features of these elements have not been described to date. There is strong evidence that, besides the myenteric nerve elements, the interstitial cells of Cajal (ICCs) and the entero-endocrine cells (EECs) should also be taken into consideration as possible sources of substances able to influence the contraction activity of smooth muscle cells (BUCHAN et al., 1983; CRIM and VIGNA, 1983; FAUSSONE-PELLEGRINI, 1987; HOLMGREN, 1985; MIKKELSEN et al., 1988; ROMBOUT and REINECKE, 1984). The aim of our study was to describe the ultrastructure of elements which may influence the contraction activity of the smooth muscle cells in the frog stomach.

Material and methods

Six adult frogs (males and females) were used in this study. The stomachs were fixed either by immersion after distension with Krebs solution (for 3hr) or by transcardial perfusion followed by immersion (for 3hr). The fixative contained 2% parafomaldehyde and 2% glutaraldehyde in 0.1 M phosphate buffer (PB) at pH 7.4 in both cases. Small tissue blocks were cut from the stomachs and postfixed in 1% OsO_4 (in 0.1 M PB) for 1hr. Blocks were then dehydrated in ascending series of ethanol, contrasted „en bloc" in 70% ethanol saturated with uranyl acetate, and embedded in Durcupan ACM resin. Ultrathin sections were cut with a Reichert OM U2 ultramicrotome and contrasted with lead citrate after REYNOLDS (1963). Preparations were viewed and photographed in Jeol EM 100B and Tesla BS 540 electron microscopes.

Results

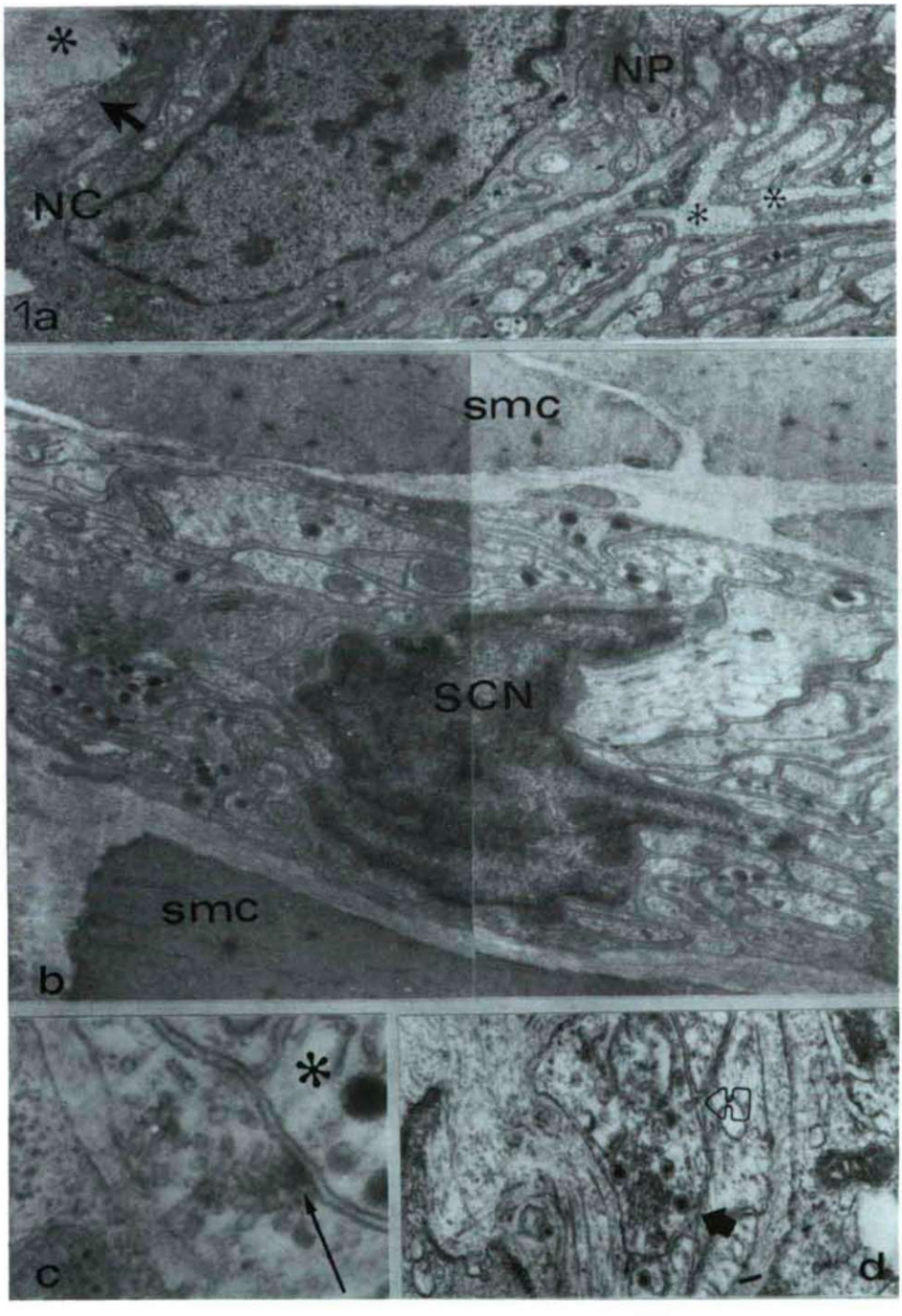
Large numbers of nerve processes and some nerve cells were revealed in the myenteric neuropile close to the outer surface of the stomach (Fig. la). Nerve cells were embedded into the main strands of the plexus. The profiles in the neuropile often contained large granulated vesicles (LGVs). The nerve cells and the surrounding neuropile were covered with Schwann-sheath and a collagen field. The interstitium was rich in collagen on the mesenteric side of the plexus. Large nerve bundles left this neuropile region to innervate the musculature of the stomach (Fig. 1b). 20—100 axons covered with Schwann-sheath were seen among the muscles. In some cases, synaptic contacts were observed between these axons (Fig. 1c), where the presynaptic density was prominent, while the postsynaptic thickening was lacking. The presynaptic profile contained clear vesicles while the postsynaptic one LGVs. Another type of contact seemed to be exocytosis between neighbouring profiles to release the transmitters from LGVs (Fig. 1d). Nerve bundles running to the muscles contained mainly 2 types of vesicles: small agranular vesicles (AGVs) and LGVs (Fig. 2a). Profiles with flattened vesicles (FVs) and also with dense-core vesicles (DCVs) were observed very rarely (Fig. 2b). Axons running parallel to the muscles sometimes established large surface close contacts, which were more than 1 μm long (Fig. 2c). As regards the junctional gap between the axolemma and the muscle cell membranes at the sites of close contacts, this did not exceed 20—40 nm

Fig. 1.a) Myenteric neuron (NC) and the surrounding neuropile (NP). The lateral side of this compact structure (arrow) is covered by Schwann cell processes. A collagen field (asterisk) can be seen between the neighbouring nerve bundles. Magnification: 7000x.

1.b) Schwann cell and axon profiles among the smooth muscle cells (smc). Some of the profiles contain large granulated vesicles (LGVs, arrows). Note the strongly heterochromatic structure of the Schwann cell nucleus (SCN). Magnification: 18000x.

1.c) Axo-axonic synapse in the deep neuropile. Only the presynaptic density (arrow) is conspicuous. The postsynaptic profile (asterisk) contain LGVs. Magnification: 32000x.

1.d) Exocytosis from a LGV. Note that the extracellular space also contains dense material (open arrow), which is probably a residue of a previous exocytotic process. Magnification: 32000x.


NP
NC
1a
smc
SCN
smc
b
c
d

(Fig. 3a), mainly where LGVs or mixed profiles established them. The release of LGVs took place with exocytosis (Fig. 3a, insert). When the contacting profiles contained AGVs only the junctional gap was approximately 100—150 nm wide (Fig. 3b).

Among the muscles, ICCs were also present (Fig. 4a), generally on the inner side of the circular muscles. Their nuclei were relatively rich in chromatin and their cytoplasm contained secretory granules of different sizes. Rough endoplasmatic reticulum cisternae, mitochondria, glycogen granules were present here (Fig. 4b).

Entero-endocrine cells were demonstrated among the epithelial cells of the frog stomach relatively frequently. They had a beanshaped nucleus and a large number of secretory granules were found in the narrow cytoplasmatic area (Fig. 4c).

Discussion

In the vertebrate alimentary canal, 3 different structures should be considered which are able to influence the contraction of the gut musculature: the nerves of the myenteric plexus, the ICCs and the EECs.

The myenteric plexus is well developed in the frog stomach and situated close to the outer surface of this organ (GÁBRIEL et al., 1987). This position is not unique among the vertebrates, for the same arangement has been observed in the gizzard of birds (ÁBRAHÁM, 1936; GABELLA and HALASY, 1987; IWANOW, 1930). The myenteric nerve cells are relatively small and not so densely packed as in higher vertebrates (GABELLA, 1987; GABELLA and HALASY, 1987; GÁBRIEL et al., 1988). The neuropile region is not so extensive as in mammals (GABELLA, 1979), and the synapses are scarce. These characteristics are typical for the lower vertebrates (BENEDECZKY et al., 1987; HALASY et al., 1988; TAXI, 1982).

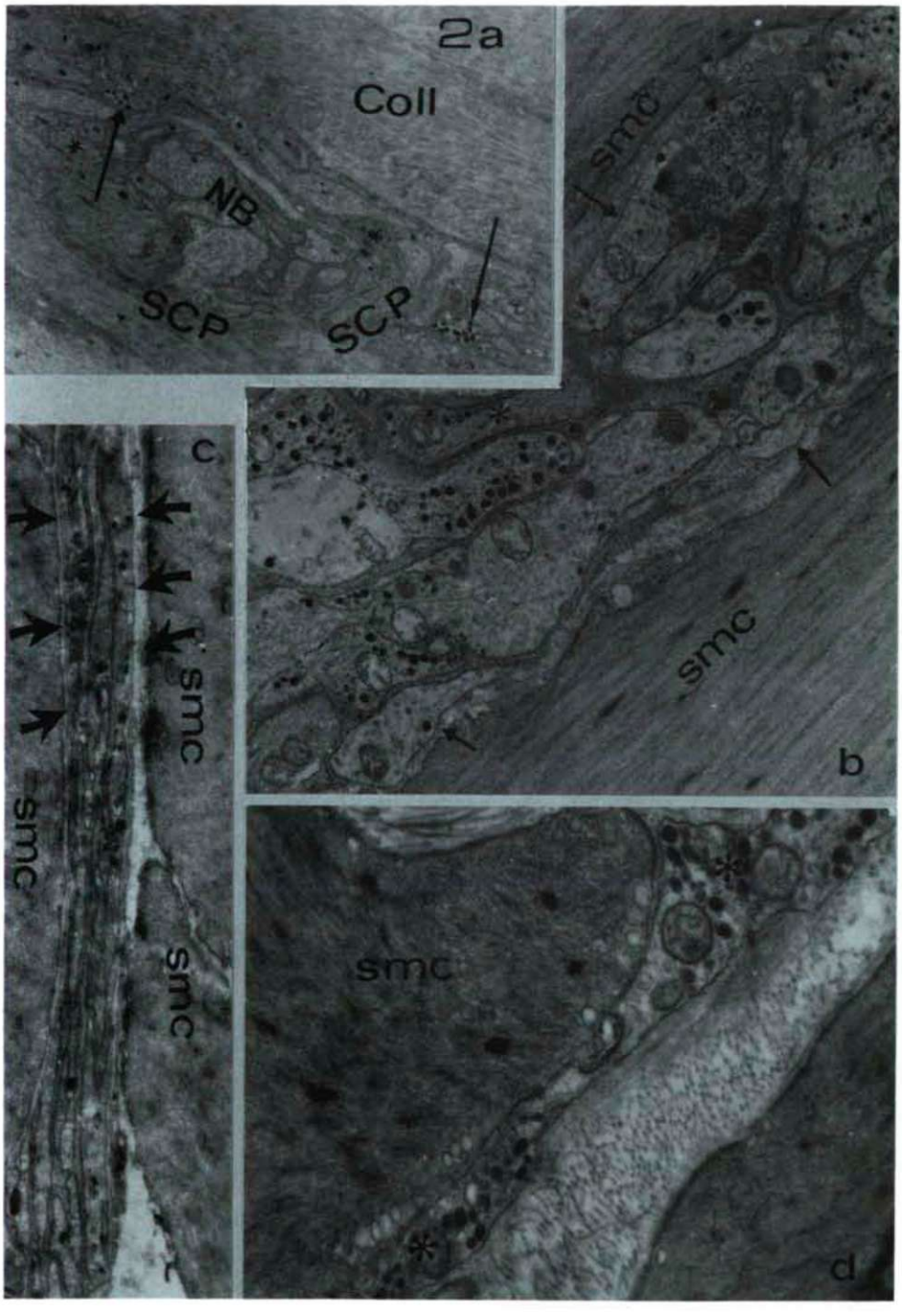
Axo-axonic synaptic contacts have been observed in the stomach, as well as in the large intestine of frog (GÁBRIEL et al., accepted for publication). Thus, this kind of synapse may be consequently present throughout the full length of the alimentary canal. Besides the synaptic contacts, another important form of communication between the different elements is non-synaptic transmitter release. The exocytosis of transmitter molecules from the DCVs and LGVs has mostly been proved with the

Fig. 2.a) Nerve bundles (NB) surrounded by collagen field (coll) among the smooth muscle cells (smc). Nerves are covered by Schwann cell prrocesses (SCP). Arrows: LGV-containing profiles; asterisks: profiles with clear vesicles. Magnification: 3400x.

2.b) Nerve plexus between smooth muscle cells (smc). Flattened vesicle (arrowhead) and dense-core vesicle (asterisk)-containing profiles are also visible. Note that a considerable proportion of the profiles are free of Schwann-sheath (arrows). Magnification: 20000x.

Fig. 2.c) Thin axons in a narrow space between smooth muscle cells (smc). Relatively long close contacts (arrows) are visible. Magnification: 18000x.

2.d) An axon with double active site (asterisks) establishes close contact with a smooth muscle cell (smc). Both vesicle accumulations contain agranular vesicles and LGVs. Magnification: 30000x.


2a
Coll
NB
SCP
SCP
smc
smc
b
c
smc
smc
smc
smc
d

TARI method (BENEDECZKY and HALASY, 1988; BUMA et al., 1984), but also described under normal EM fixation conditions (ZHU et al., 1986).

As concerns the possible transmitters, acetylcholine is known to play this role in the frog stomach (RASHID, 1972; WONG et al., 1971), and also the presence of γ-aminobutyric acid has been proved (GÁBRIEL and ECKERT, 1989). BURNSTOCK (1972) postulated the purinergic hypothesis, which was also discussed by SNEDDON et al. (1973). However, morphological investigations have not yet been performed in this respect. No evidence has been obtained on the presence of peptide transmitters so far, but the axon profiles with mixed vesicle content suggest cotransmission (BURNSTOCK, 1976, 1978; HÖKFELT et al., 1977; SCHULTZBERG et al., 1980). Because of the great number of muscle contacting LGV and mixed profiles, the role of peptide/purine neurotransmission is of significance in the frog stomach. The most important peptide transmitter candidate is Substance P, which is known to have a strong stimulating effect on muscles and also on other nerve endings, in both lower (BJENNING and HOLMGREN, 1988; JENSEN et al., 1987) and higher vertebrates (BARTHO and HOLZER, 1985; SMITH et al., 1988).

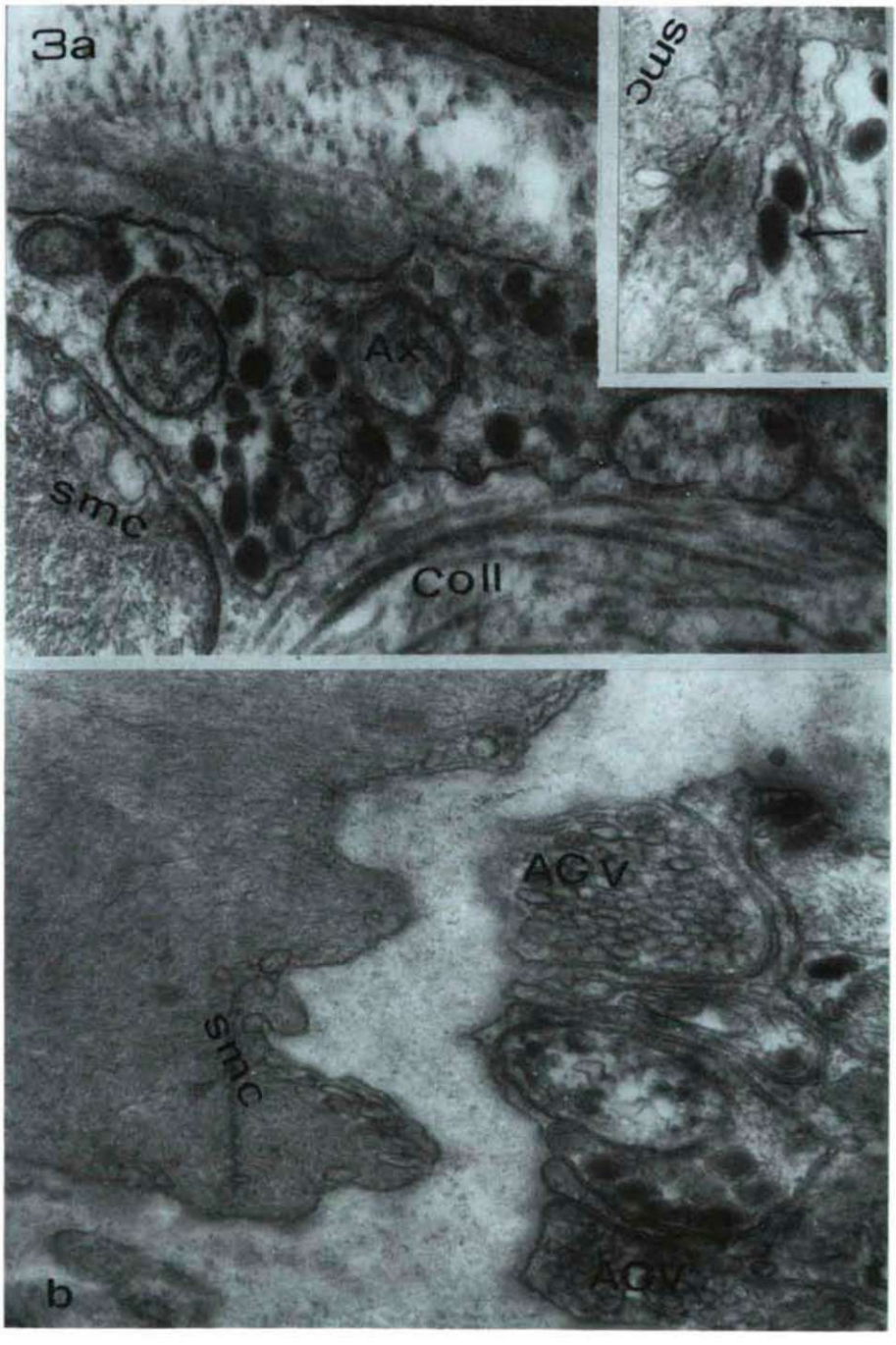
The first description of ICCs was reported by CAJAL (1893). Their presence in the frog stomach muscular layer was revealed by COLE (1925). Descriptions at the EM level are available on the ICCs of different mammals (FAUSSONE-PELLEGRINI, 1984, 1987), but not those of the frog stomach. The general view of ICCs in the frog stomach is not basically different from that for mammals. The smaller amount of smooth endoplasmatic reticulum of the frog ICCs may be considered to be the only main morphological difference. The role of these cells remains obscure almost a century after CAJAL, although some authors (FAUSSONE-PELLEGRINI, 1984, 1985; STACH, 1972; TAYLOR at al., 1977) regard them as an element of a functional chain: nerve endings-ICCs-smooth muscles. The ICCs might act as pacemakers which are controlled by nerve endings. Further studies are needed to ascertain the exact role of these cells.

EECs are known to contain serotonin and different peptides (CCK-gastrin, bombesin, somatostatin) in the lower vertebrates, too (CRIM and VIGNA, 1983; ROMBOUT and REINECKE, 1984). The presence of a high amount of secretory granules in these cells suggests that an intensive peptide-secreting process occurs here. The same granules may also contain serotonin, because PELLETIER et al. (1981) poved the presence of serotonin and a peptide (Substance P) within one DCV. These substances might act through the local circulatory system and also by diffusion across the connective tissue layer. The seasonally different effects of

Fig. 3.a) The junctional gap is not more than 20—50 nm when the contacting profile (Ax) includes LGVs. Coll: collagen, smc: smooth muscle cell. Magnification: 32000x.

Insert: exocytosis (arrow) in the close proximity of a smooth muscle cell (smc). Magnification: 64000x.

3.b) When the contacting profile contains agranular vesicles (AGV), the junctional gap is slightly more than 100 nm. smc: smooth muscle cell. Magnification: 60000x.


3a
smc
Ax
smc
Coll
AGV
smc
AGV
b

serotonin on the frog stomach were clarified by SINGH (1964); he found that this substance has an excitatory effect in spring and an inhibitory effect in other seasons.

In conclusion, the 3 different structures described here influence the smooth muscle activity in a complex manner, in 3 different ways: (1) nerves may act directly on the smooth muscle cells; (2) the ICCs are able to change their own pacemaker activity (also influenced by nerves?); and (3) the active substances of the EECs (serotonin and peptides) might act through the local circulatory system.

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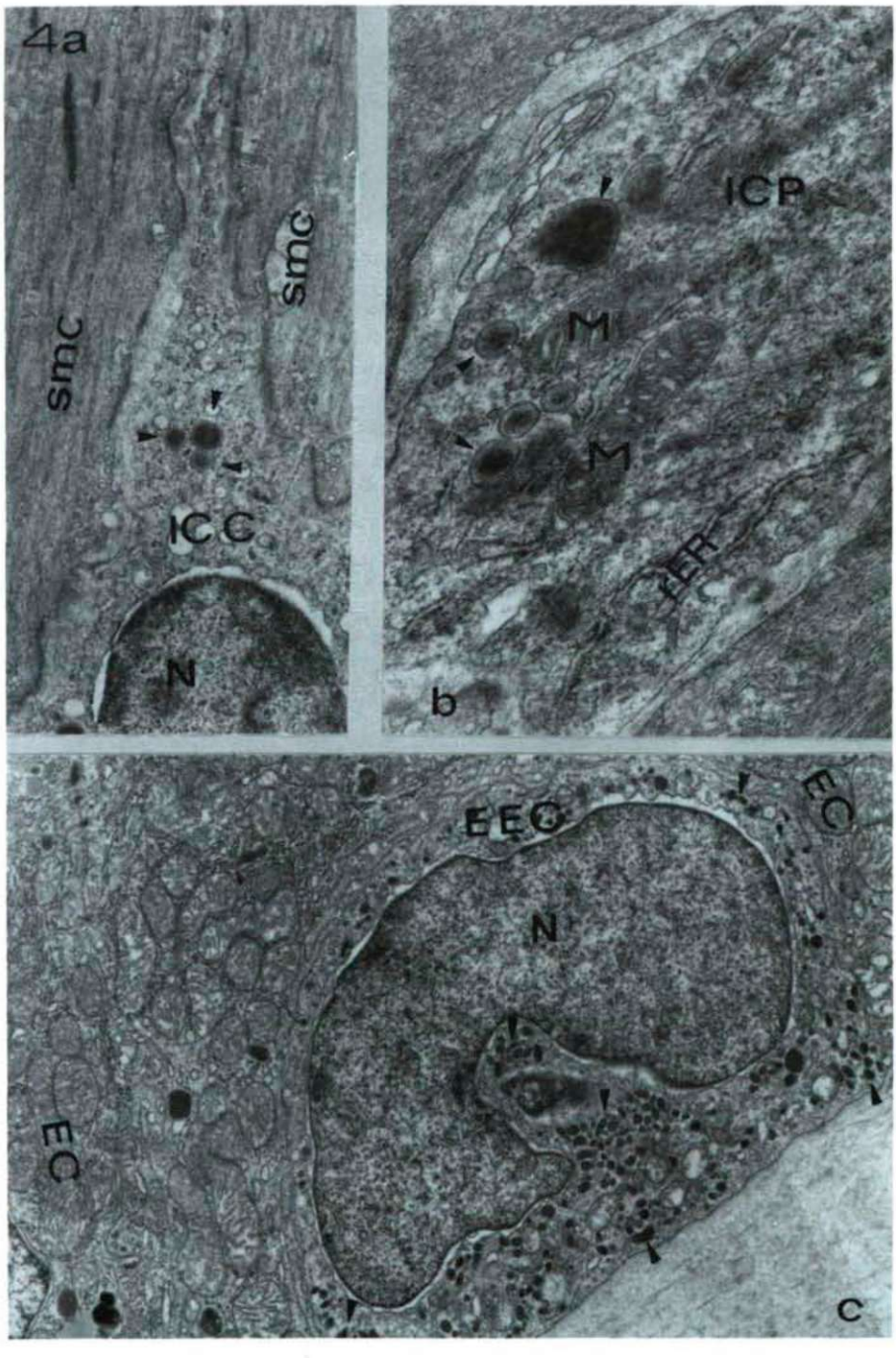
Fig. 4.a) ICCs are often present between the smooth muscle cells (smc). The nucleus (N) is rich in chromatin, and the cytoplasm contains secretory granules (arrowheads). Magnification: 34000x.

4.b) The ICC processes (ICP) form knobs between the muscles: mitochondria (M), rough endoplasmatic reticulum (rER) and granules (arrowheads) are also present. Magnification: 34000x.

4.c) EEC among other epithelial cells (EC). A bean-shaped nucleus (N) and large amount of secretory granules (arrowheads) are characteristic of it. Magnification: 18000x.


4a
smc
smc
ICC
N
ICP
M
M
SER
b
EEC
EC
N
EC
c

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RECEPTOR CELL RENEWAL IN THE SENSORY EPITHELIA OF THE LIP OF THE SNAIL HELIX POMATIA L.

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Abstract

^{3}H-thymidine incorporation was investigated in the sensory epithelia of the lips of *Helix pomatia* by light microscopic autoradiography. Labelled cells were observed among the epithelial cells as well as in the sensory lobules. After a short survival time following the ^{3}H-timidine injection only heavily labelled cells could be detected. The heavily labelled cells in the receptor cell areas were always located at the periphery of the sensory lobules. After a long survival time the lightly labelled cells appeared and became dominant; they were always observed among the sensory cells in the sensory lobules. The number of labelled cells increased during short survival times (30 min, 4h) but later a continuous decrease was observed. This demonstrates a slow but continuous renewal and maturation of the sensory and epithelial cells in the sensory epithelia of the snail *Helix pomatia*.
Key words: *Helix pomatia*, lip, sensory epithelia, receptor cells

Introduction

Gastropods receptor areas such as the lips and body wall seem to have the general ability of both chemo- and mechano-reception (SCHULTZ, 1938; KIECKEBUSH, 1953; KITTEL, 1956; STEPHENSON, 1979; CROLL and CHASE, 1980; CHASE and CROLL, 1981; CHASE, 1982; HERNÁDI et al., 1984; KEMENES et al., 1985.) According to the Golgi impregnation studies, the receptor areas of the body wall are densely innervated by primary sensory neurons (SCHULTZ, 1938; DEMAL, 1955; HERNÁDI, 1982). The ultrastructural studies have concentrated on sensory dendrites to establish a relationship between the sensory dendrites with different ultrastructural characteristics and the different receptor modalities. Numerous types of dendrites could be separated on the basis of their fine structural characteristics, and different receptor modalities have been correlated with them (ZYLSTRA, 1972; WRIGHT, 1974; WONDRAK, 1975; KATAOKA, 1976; BENEDECZKY, 1977, 1979; CROLL, 1983). The sensory dendrites in the sensory epithelia of the tentacles, the lips and the foot of *Helix pomatia* were classified into a series of transitional forms on the basis of their fine structural characteristics (the number of cilia and microvilli, the length of the roots of cilia, the width of the apical dendritic surface, the density of the dendritic cytoplasm). These transitional forms spread from the microvillous dendrites with centrioles through the dendrites possessing 1—2 cilia and microvilli with centrioles in their apical parts, to the

dendrites possessing numerous cilia on their apical surfaces (HERNÁDI and BENEDECZKY, 1978, 1983). It was supposed that this great variation in the structural appearance of the sensory dendrites could be explained by a renewal process of the primary sensory neurons (HERNÁDI and BENEDECZKY, 1978, 1983; HERNÁDI, 1981 a, b, TOTARO et al., 1984) similar to that in the vertebrate olfactory epithelia (GRAZIADEI and METCALF, 1971; MOULTON, 1974; HARDING et al., 1977; GRAZIADEI and MONTI GRAZIADEI, 1979). The aim of the present study was to demonstrate mitotic elements in the sensory lobules of the lips by applying light microscopical ^{3}H-thymidine autoradiography and in this way to prove the sensory cell renewal in the sensory epithelia of *Helix pomatia*.

Materials and Methods

Adult specimens of *Helix pomatia* were used for the experiments. 15 μCi ^{3}H-thymidine/gr body weight was injected into the body cavity of each animal diluted in 250 μl ringer solution. The animals were sacrificed at 30 min, 4h, 1 day, 1 week, 2 weeks, and 1 month survival time following the injection. The lips were excised and fixed in 2.5% glutaraldehyde buffered with 0.1 M sodium cacodylate buffer (pH: 7.2) for 4h at 4 °C. After a short wash in the buffer the samples were postfixed in 1% OsO_4 buffered with 0.1 M s-collidine (pH: 7.4) for 2h at 4 °C. After fixation the samples were dehydrated through increasing concentration of ethanol and were embedded into Spurr media through propileneoxid. Serial sections consisting of 8—10 1μm thick cross sections containing the whole width of the sensory epithelia were cut and dried on slides and counterstained with toluidine blue. The sections were covered with Ilford L4 emulsion. After two weeks exposition the slides were developed with Kodak D—19 developer. The cells were considered to be labelled if there were at least 5 grain over their nucleus.

Results

In the 1 μm thick toluidine blue stained cross sections the lobular organization of the receptor cells as well as the typical structure of the lips are clearly visible (Fig. 1.). The different cellular elements can be separated on the basis of their typical morphological characteristics (e. g. diameter and the heterochromatin pattern of the nucleus). Labelled cells can be observed in the sensory lobules and among the epithelial cells. Nonsensory neuronal elements do not have grains over their nuclei. After a short survival time (30 min) only heavily labelled cells can be detected with numerous silver grains over their nuclei. These cells can be observed usually as pairs both among the epithelial cells located on the basal lamina (Fig. 2) and in the region of the sensory lobulus (Fig. 3). The heavily labelled cells are usually located at the periphery of the lobules (Fig. 3). Of the 6—8 lobules in the investigated section only 1—2 contained heavily labelled cell pairs. After a longer survival time (4h) the number of heavily labelled cells increases and lightly labelled cells begin to appear among the sensory cells in the lobulus. These lightly labelled cells have only 5—10 silver grains over their nucleus (Fig. 4). At short survival times (30 min to 4h) the heavily labelled cells are dominant, but after a longer survival time (1 day) the number of lightly labelled cells inreases, and these become dominant. Heavily

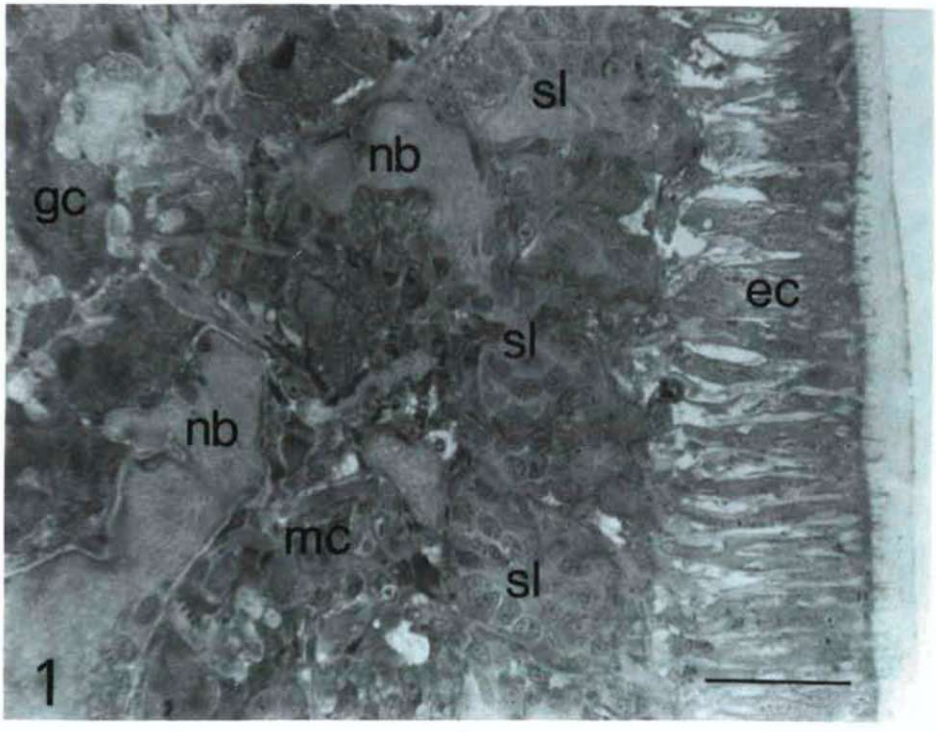
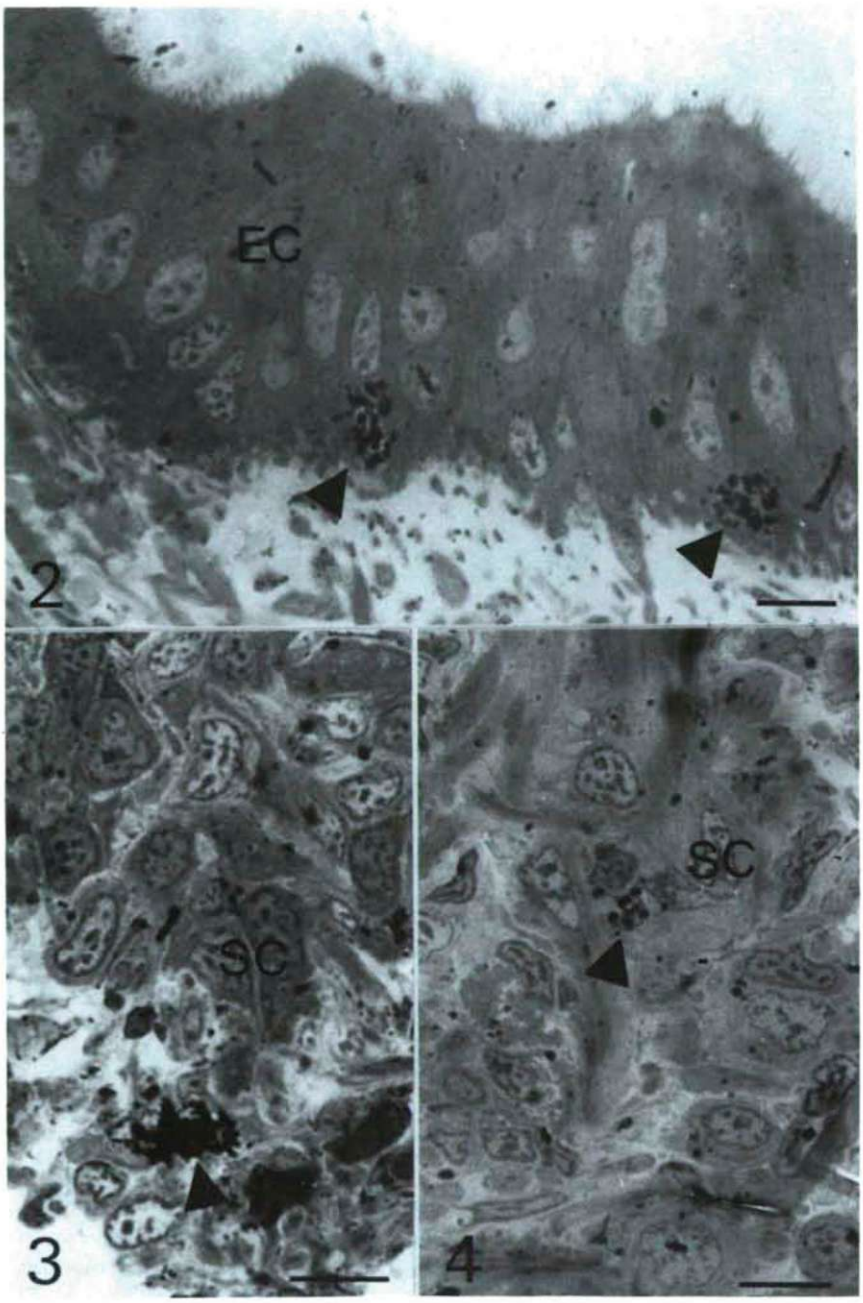


Fig. 1. The semithin section of the lip demonstrates the typical organization of the sensory epithelium. Under the epithelial cell layer (ec) sensory lobules (sl) are located. The nerve branches (nb) of the medial lip nerve reach the sensory lobules. Under the sensory lobules muscle cells (mc) and gland cells (gc) can be seen. scale bar: 50 μm

labelled cells, however can be observed even after 30 day survival but only scarcely among both the sensory and the epithelial cells. The number of labelled cells decreases in time. By the 30th day their number is about 60% of that observed at 4h survival. At this time only one lightly labelled cell can be detected in the cross section.

Discussion

According to the ^{3}H-thymidine autoradiography numerous mitotic elements can be observed both among the epithelial cells and the sensory neurons in the sensory epithelia of the lips. Our findings show that the sensory neurons originate from stem cells that undergo a slow mitotic process producing heavily labelled cell pairs that undergo a second mitosis which produces the lightly labelled cells. Following the ^{3}H-thymidine injection, the number of heavily labelled cells


EC
2
SC
3
SC
4

increased; in time, however, all of the labelled cells decreased in number. Therefore, the mass of primary sensory neurons in snails undergoes a spontaneous and continuous process of renewal and maturation, which last from mitosis to neuronal death. Similar findings were demonstrated recently in the tentacles of *Achatina fulica* (CHASE and RIELING, 1986). According to these observations, the primary sensory neurons in the snail sensory epithelia behave similarly to the primary olfactory sensory neurons in vertebrate olfactory epithelia (GRAZIADEI and METCALF, 1971; MOULTON, 1974; GRAZIADEI and MONTI GRAZIADEI, 1979). This maturation process can explain the previously described great structural variety of the primary sensory neurons in the sensory epithelia of the *Helix* tentacles and lips (HERNÁDI and BENEDECZKY, 1978, 1983, HERNÁDI 1981).

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Fig. 2. At short survival time (30 min) heavily labelled cell pairs (triangles) can be seen among the epithelial cells (EC). scale bar: 10 μm

Fig. 3. At the periphery of the sensory lobules heavily labelled cell pair (triangle) can be detected after a short survival time (30 min) following the ^{3}H-timidine injection. SC: sensory cell, scale bar: 10 μm

Fig. 4. At long survival time (1 day) lightly labelled cell (triangle) can be seen among the sensory cells (SC). scale bar: 10 μm

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THE INNERVATION OF THE MUSCLE AND GLAND CELLS IN THE LIP OF THE SNAIL HELIX POMATIA L.

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Abstract

According to intensificated Co-labelling, both thick and thin nerve fibres innervate the muscle and gland cells, though the gland cells are predominantly innervated by thin fibres with small varicosities. The muscle cells are innervated by both serotonin and FMRFamide containing fibres with small varicosities. Among the gland cells immunoreactive fibres can scarcely be observed. The innervating fibres may partly originate from the cerebral ganglion since numerous cell bodies sending axonal processes to the lip became labelled after backfilling the lip branch of the medial lip nerve with Ni-lysine; and some of them proved to be serotonergic after 5,6-DHT treatment.
Key words: Helix pomatia, lip, innervation, muscle, gland

Introduction

It has been demonstrated that both central and peripheral neuronal elements take part in the regulation of the movements of the oral lobes during feeding behavior in *Helix pomatia* (KEMENES et al., 1982; HERNÁDI et al., 1984, 1987). In order to understand animal behaviour at the neuronal level, it is necessary to elucidate the neuronal connections at the peripheral level in effector organs as well as in the central nervous system (CNS). In the *Helix* lip, which is an effector organ taking part in feeding movements (SCHULTZ, 1938; KIECKEBUSH, 1953; KEMENES et al., 1985), the musculature and glandular mass are targets of both the central and peripheral nervous systems. The aim of this study was to investigate the innervation of muscle and gland cells by using Cobalt labelling of the innervating neuronal fibres. Furthermore, pigment induction and light microscopical immunocytochemistry were used to characterise the transmitter or modulator content of the innervating neuronal fibres by applying 5,6-DHT as well as serotonin (5HT) and FMRFamide antibodies.

Materials and methods

Adult specimens of the snail *Helix pomatia* were used for the experiments. The ganglion complex (CNS) and the lip with the medial lip nerve were excised and fixed on silgar with small needles. The lip branch of the medial lip nerve was cut, and the distal end was put into an open vaselin cup containing aqueous solution of Cobaltic-lysine (200 μM). Thereafter the cup was enclosed with vaseline and the

preparation was covered with ringer solution. After 48h exposure at 4 °C, the Co ions in the lip were precipitated in a cold phosphate buffer (pH 7.4) saturated with H_2S gas. The lip was dehydrated and embedded in paraffin, and 20 μm thick serial sections were cut. After deparaffination the serial sections were subjected to intensification procedure (GÖRCS et al., 1979; HERNÁDI et al., 1987) to visualize the Co-sulfide in the nerve fibres. After intensification the serial sections were dehydrated and covered with canadabalsam and studied with a light microscope.

In order to determine the localization and the serotonergic nature of the neurons sending axonal processes to the lip, 5,6-dihydroxytryptamine neurotoxine was injected into the body cavity of each animal in a dose of 10 mg/kg body weight which induces the pigmentation of the serotonergic neurons (S-RÓZSA et al., 1986; HERNÁDI et al., 1988, 1989). Thereafter the CNS was excised and Nickel-lysine backfilling was done through the proximal end of the lip branch of the medial lip nerve that was put into a vaselin cup containing 200 μM Ni-lysine. After 48h transporting time the Ni ions were visualized with rubeanic acid giving a bluish colour (QUICK and BRACE, 1979; HERNÁDI et al., 1984) to the neurons that send axonal processes to the lip. The serotonergic neurons sending axons into the lip had bluish colorization and contained rusty-brown pigment granules in their somata. The CNSs were dehydrated, embedded into canadabalsam and studied as whole mount preparations. The map of the Ni — labelled blue and the double labelled (blue and pigmented) serotonergic neurons was drawn from microscope by using a drawing apparatus.

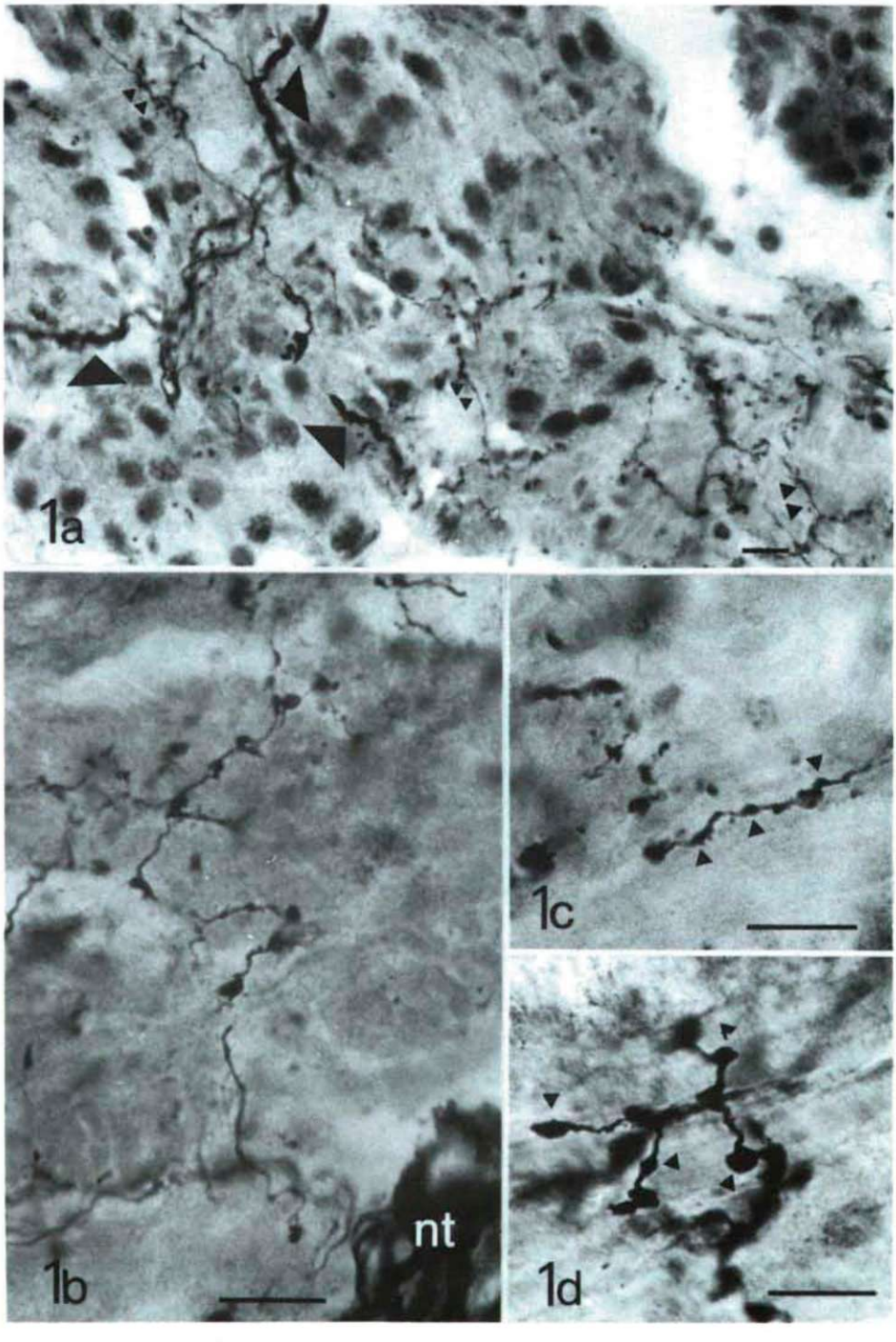
For light microscopical immunocytochemistry the lips were fixed in 4% paraformaldehyde in 0.1 M phosphate buffer (pH 7.4) for 12h at 4 °C and were washed overnight in the buffer. The samples were dehydrated and embedded in paraffin. Immunocytochemical procedure was performed on 15 μm thick deparaffinated sections according to Sternberger (1979). Both the serotonin and FMRFamide antibodies were used in 1:3000 dilution in phosphate buffered saline containing 0.3% Triton X—100 (PBSTX). Antiserum specificity for 5HT and FMRFamide was tested by replacing the primary antibody with normal rabbit serum at the same dilution. After the development of the immunocytochemical reaction with DAB-H_2O_2 the sections were dehydrated in ethanol followed by xylene and covered with canadabalsam.

Results

LIGHT MICROSCOPICAL ANALYSIS OF THE INTENSIFICATED SERIAL SECTIONS

In the serial sections a dense labelled fibre system can be observed (Fig. 1.a). The majority of the labelled fibres can be observed in the musculature, while in the glandular mass intermingled with muscle cells only a few groups of labelled fibres can be detected running parallel with the gland cells (Fig. 2.a). The labelled fibres that originate from large labelled nerve trunk (Fig. 1.b) run over the muscle cells have different diamaters and numerous varicosities (Fig. 1.a). The varicosities are either small or large on the labelled fibres (Fig. 1.c, d). Among the gland cells nerve fibres with small varicosities are dominant (Fig. 2.b) while fibres with large varicosities can only scarcely be observed (Fig. 2.c).

Fig. 1. In the intensificated section of the lip a rich arborization of the innervating fibres can be seen in the musculature, consisting of thin (small triangles) and thick (large triangles) nerve fibres (Fig. 1.a). The solitary fibres originate from large labelled nerve trunks (nt) (Fig. 1.b). The labelled fibres have small (Fig. 1.c) or large (Fig. 1.d) varicosities (small triangles) over the muscle cells. scale bars: 10 μm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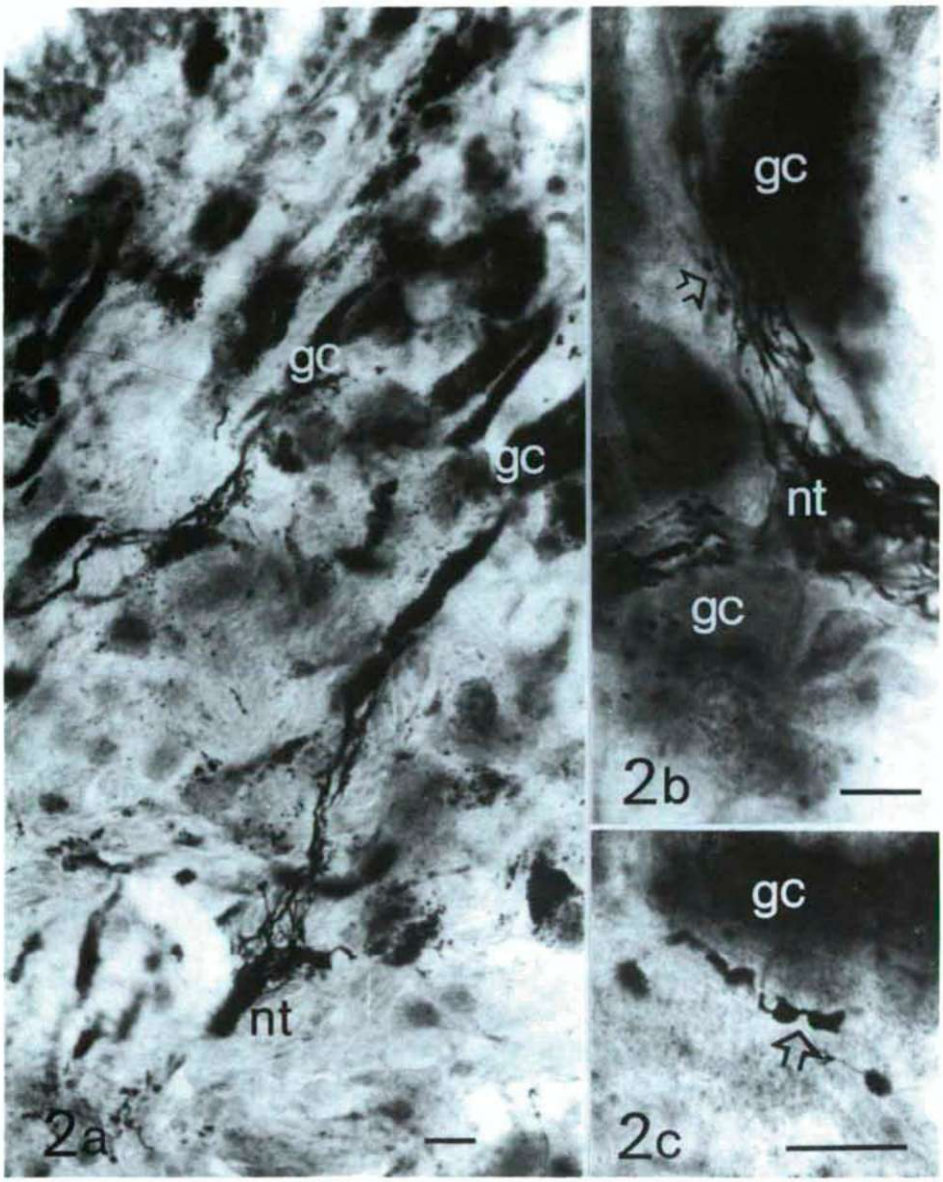


Fig. 2. Among the gland cells (gc) small trunks of labelled fibres (nt) run parallel with the gland cells (Fig. 2.a). The labelled fibres invaginate into the gland cells and have small (Fig. 2.b) and large (Fig. 2.c) varicosities on them (open arrows). scale bars: 10 μm

FMRFAMIDE AND SEROTONIN (5HT) IMMUNOREACTIVE ELEMENTS IN THE LIP

FMRFamide immunoreactive fibres were frequently detected in the musculature of the lip, but only scarcely among the gland cells (Fig. 3.). Immunoreactive fibres are observable in nerve trunks and also as solitary fibres with small varicosities among the muscle cells (Fig. 3.). Immunoreactive nerve cell bodies cannot be detected.

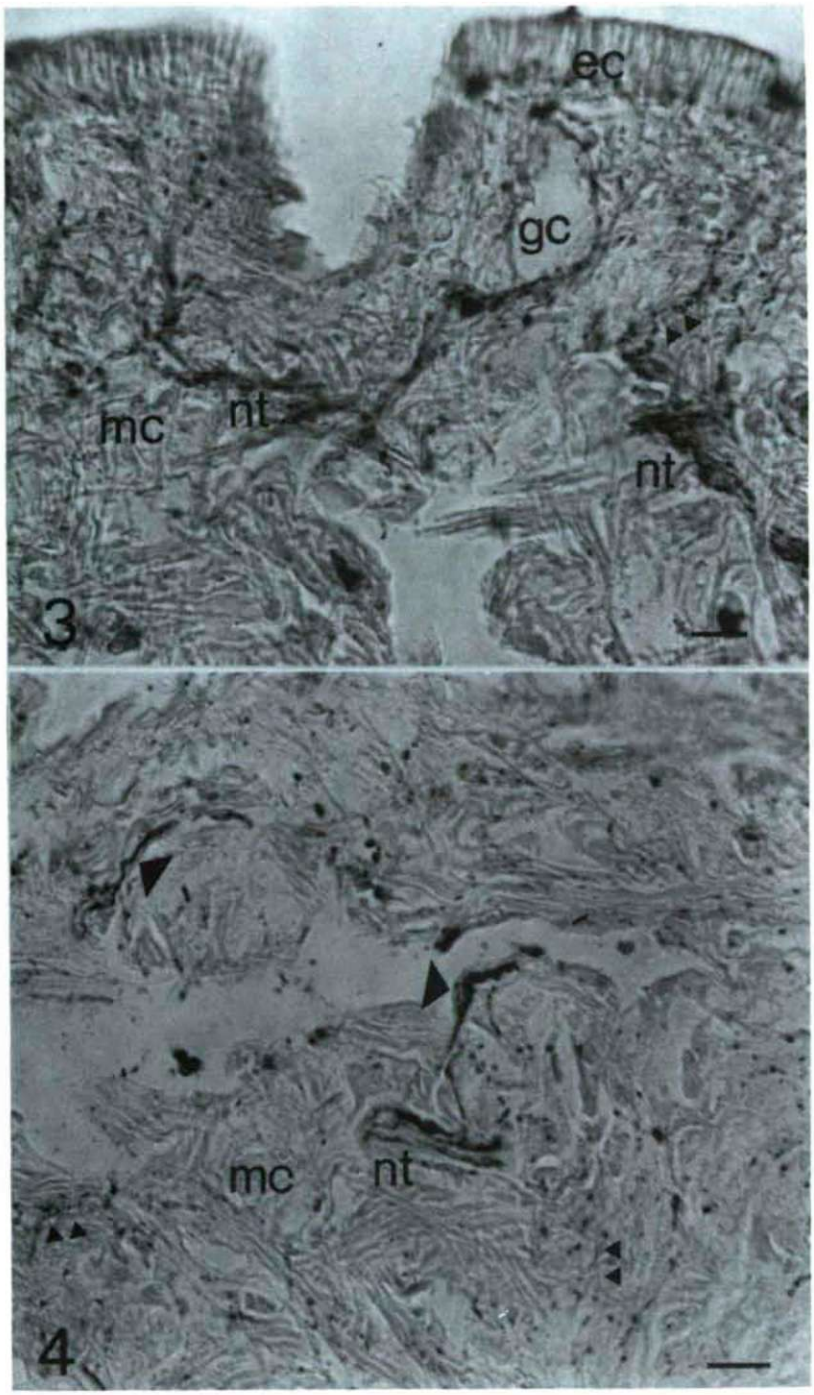
5HT-immunoreactive fibres can be seen all over the musculature of the lip but rarely seen among the gland cells (Fig. 4.). The immunoreactive fibres run in groups in the nerve trunk or as thin and thick solitary fibres among the muscle cells. Numerous varicosities can be observed on single immunoreactive fibres. Immunoreactive neuronal somata cannot be seen in the sections.

MAPPING OF CEREBRAL NEURONS THAT SEND AXONAL PROCESSES TO THE LIP

In the cerebral ganglion the neuronal cell bodies that send axonal processes to the lip can be seen as blue cells after Ni-lysine backfilling of the nerve branch of the medial lip nerve. Blue labelled neurons can be detected in all parts of the cerebral ganglion, but they are dominant on the ventral surface (Fig. 5.). The serotonergic neurons appear as rusty-brown pigmented cell bodies after 5,6-DHT injection. They are located only on the ventral surface of the cerebral ganglion (detailed description see: S-RÓZSA et al., 1986; HERNÁDI et al., 1988, 1989). After Ni-lysine backfilling 12—15 pigmented serotonergic neurons become blue coloured in the metacerebrum around the metacerebral giant cell (MGC) (Fig. 5.).

Discussion

In the lip the organization of the muscle cells into longitudinal and transversal fibres is similar to that described in the body wall of other gastropod species (ROGERS, 1968, 1969; PLESCH, 1977). According to the analysis of the intensificated Co-labelled fibres, the lip musculature and glandular mass are innervated by numerous thin and thick labelled fibres with small and large varicosities, which demonstrate that they are innervated by two morphological types of fibres. The gland cells are innervated predominantly by thin fibres with small varicosities, while the muscle cells are innervated by a roughly equal number of both thin and thick fibres. On the basis of the Co-lysine backfilling of the lip as well as the Ni-lysine backfilling of the cerebral ganglion, the innervating fibres may originate partly from the labelled neurons located in the lip and partly from the labelled neurons in the cerebral ganglion that send neural processes to the lip through the medial lip nerve. According to the light microscopical immunocytochemistry both 5-HT and FMRFamide immunoreactive fibres can be seen in the lip. The distribution of the 5-HT and FMRFamide immunoreactive fibres is similar; they are dominant among the muscle cells and have small varicosities. Among the gland cells intermingled with muscle cells these fibres can scarcely be observed. The morphological appearance of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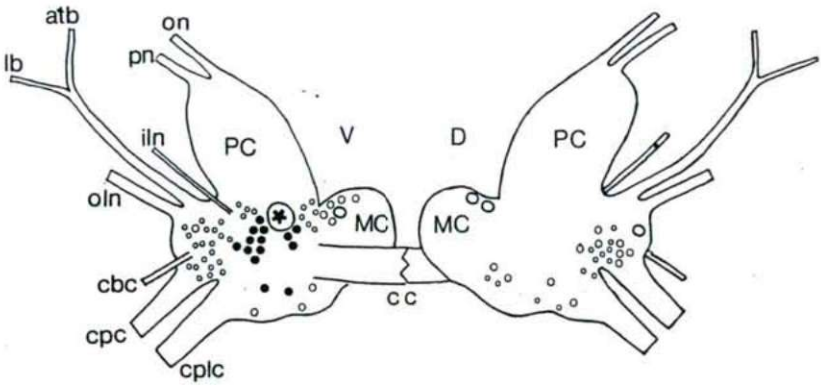

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Fig. 5. The distribution of Ni-labelled cerebral neurons sending axonal processes to the lip on the surface of the cerebral ganglion after, 5,6-DHT pigmentinduction. dark simbols: nickel-labelled pigmented serotonergic neurons, open simbols: nickel-labelled non pigmented neurons, cbc: cerebro-buccal connective, cc: cerebral comissure, cplc: cerebro-pleural connective, cpdc: cerebro-pedal connective, iln: inner labial nerve, mln: medial labial nerve, oln: outer labial nerve, on: olfactory nerve, pn: penis nerve, lb: lip branch of the medial lip nerve, tb: anterior tentacular branch of the medial lip nerve, PC: procerebrum, MC: mesocerebrum, asterisk: Metacerebral giant cell. scale bar: 10 μm

the 5-HT and FMRFamide immunoreactive fibres are very similar to the thin Co-labelled fibres with small varicosities. Therefore, it is difficult to establish whether they contain both 5-HT and FMRFamide in the same fibre or whether they represent separate morphological types of innervating fibres. The 5-HT and FMRFamide immunoreactive fibres may originate from the cerebral ganglion since neither 5-HT nor FMRFamide immunoreactive cell bodies were observed in the lip, but numerous Ni-labelled bluish neurons proved to be serotonergic in the cerebral ganglion sending axonal processes to the lip demonstrating the dominancy of the CNS in the serotonergic and FMRFamidergic innervation.

Fig. 3. FMRFamide immunoreactive fibres (Fig. 3.) can be frequently detected in the paraffin section of the lip. The thin labelled fibres are branching from nerve trunks (nt) and have small varicosities (triangles) among the muscle cells (mc) but not among the gland cells (gc). Nerve cell bodies can not be observed in the sections. ec: epithelial cell layer; scale bar: 10 μm

Fig. 4. Serotonin immunoreactive fibres can be observed predominantly among the muscle cells (mc). The labelled fibres have thick (large triangles) and thin appearances with varicosities (small triangles). nt: nerve trunk. scale bar: 10 μm

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MOVEMENTS OF PHYTOPHAGOUS INSECT POPULATIONS BETWEEN UNGRAZED SANDY GRASSLAND AND ADJACENT AREAS

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Abstract

Movement behaviour of *Auchenorrhyncha* and *Acridoidea* populations was studied in the boundary zones of ungrazed grassland patches and their surroundings on a sandy pasture field, at 0—50 cm height. The probability of the direction of movements was estimated by maximum likelihood method and chi square test.

Movements of 17 *Auchenorrhyncha* species (15%) were more or less directed. The ungrazed grassland supplied species for grazed areas mainly in the spring season, while in the dry summer period its „refuge" character became important as it was established from the increas of immigration from the pasture.

More marked directionality was observed in the movements of dominant grasshopper populations. The *Acridoidea* community of ungrazed area was continuously, intensively supplied from the pasture, and this tendency culminated in the summer. The movements were less intense in the boundary zone of the forest, and this means the retaining, attractive effect of the ungrazed patch.
Key words: Acridoidea, Auchenorrhyncha, direction, movement, sandy grassland, window-trap

Introduction

Composition and spatio-temporal patterns of ecological communities at a habitat are influenced by the interactions with exterior communities. The intensity of these interactions depends on the similarity or dissimilarity of communities, on the degree of their isolation, on the size of the habitat, etc. In case of insect populations the most common manifestation of this relationship is in movement activities. Understandable, that the investigations of different movement types are frequent.

One of the extreme cases of asimmetric migrational relationships between communities of adjacent habitats is, when either fauna needs continuous supply (DELETTRE, 1986). There are partly similar seasonal migration relationships between the fauna of cultivated plants and that of connected bordering of weed (BEIRNE, 1956; ITO and MIYASHITA, 1961; ARZONE and VIDANO, 1984; etc.). In contradiction to these temporal habitats, the relationships of populations of continuously connected communities are more complicated, because in this case the possibility of continuous scattering exists (PURCELL and FRAZIER, 1985). The scattering individuals may utilize the surrounding patches as reservior (BLOCKER et al., 1972), wintering or feeding sites (WALOFF, 1973), or to complete their life cycles

(TAYLOR, 1985). The survival strategies coupled with migration or dispersion are well known (SYMMONS and MCCULLOCH, 1980; ROFF, 1975; ROBERTS, 1978; MARINO, 1986, etc.).

If we want to study the turnover of individuals of two contiguous habitats, it seems obvious that we would measure the movement of insects in the boundary zone. We can choose the layer of active flight (boundary layer), where the flight speed of insects is larger than the wind speed (TAYLOR, 1974). Over this the individuals that passed the „boundary layer interface" spread inactively. This movement is considered as the true migration (TERAGUCHI, 1986). Height of the boundary layer interface between active and passive spreed is changing from 30 cm to several meters in certain insect groups (TAYLOR, 1974). On the basis of literature, in our opinion the examination of active flight's zone indicates more precisely the flyings in from short distances (since the efficiency of gathering depends considerably on the distance from the trap (RAATIKAINEN and VASARAINEN, 1973), and this helps to eliminate the effect of wind near the soil surface (MEDLER, 1962).

The aim of this study is to investigate the movements in two insect communities in the boundary layer between an ungrazed grassland patch and the connecting pasture and forest, respectively. We want to draw a conclusion about, what is the degree of independence of the two communities with different indication of spatial heterogeneity (coarse grained or fine grained (GALLÉ et al., 1985), at habitats connected through boundary zones, and to what extent is similar or dissimilar the degree and direction of the seasonal individual turnover of their populations?

Materials and methods

THE EXAMINED AREA

Investigations were carried out in the Bugac region of KNP at the 2.4 ha part of a sandy pasture that is free of grazing from 1976. At the southern, longer side this plot is adjacent to the wide pasture, that has been still used. At the opposite, northeastern side a 2—3 m broad earth road and a young aspen forest are situated. The surrounded area is heteromorphous because of the varied relief with sand hills and wind grooves, and on the other hand of mosaic-like pattern of vegetation that represent different successional stages. Three associations of varied patch size dominate the experimental area: 1. *Potentillo-Festucetum pseudovinae*; 2. *Festucetum vaginatae danubiale*; and 3. *Molinio-Salicetum rosmarinifoliae*. For detailed description of vegetation see KÖRMÖCZI et al., 1981; BODROGKÖZY and FARKAS, 1981.

COLLECTING METHODS

10—10 window traps were placed along the two longer sides of the experimental area (Fig. 1.). The size of collecting dishes was 50x25x5 cm, filled with ethyleneglycol as destroying agent. 2—2 dishes were divided by glass plate which was 50 cm high. The traps were placed parallel with the border line of the area to separate the entering and leaving individuals. Traps worked from March to November each year, samples were collected in general fortnightly. In 1981 the samples were collected at heights of 0—50, 50—100 and 100—150 cm to determine the correlation between efficiency of collecting and height. In 1982 the two lower levels were used, and on the basis of their results in 1983 we evaluated only the material of the lowermost dishes. In 1982 we placed a trap with 6 dishes in the forest, 10 m from the edge of aspen woods, to estimate the populations moving there.

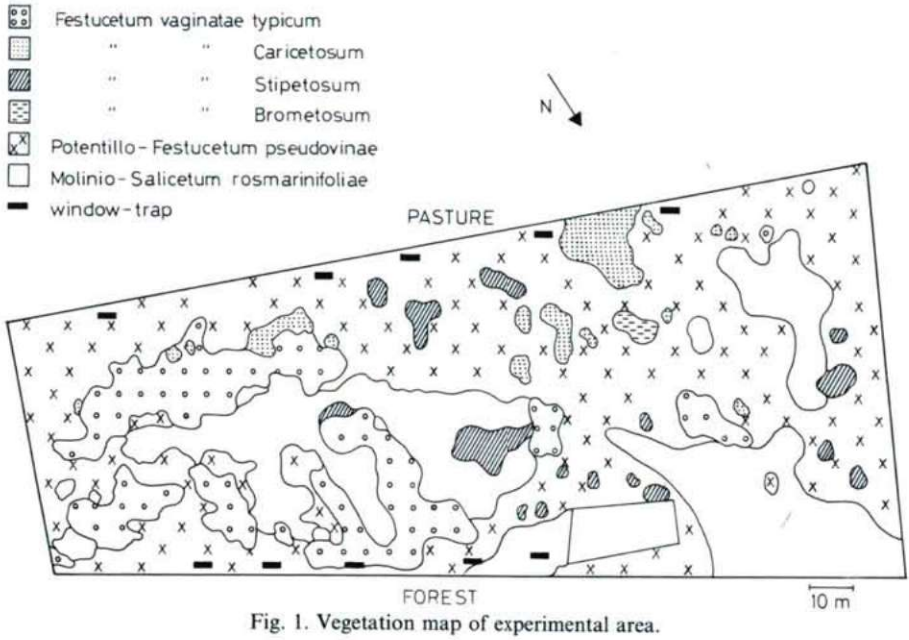

Fig. 1. Vegetation map of experimental area.

PROCESSING METHODS

1. For statistical evaluation of movement direction of populations entering or leaving the experimental area we used the maximum likelihood estimation of Bernoulli binomial distribution. We started from the proportion of the number of entering individuals to that of leaving individuals in case of both boundary zones. We examined the validity of the following two conditions:

a) We supposed, that the movement is undirected, in this case the number of individuals caught at opposite sides of the trap must be nearly the same, that can be controlled in the traps or in groups of traps.

b) If the movement is directed, the number of individuals at opposite sides of the traps would be different, and the direction of differences is the same.

2. Significant difference of the two sides was controlled also by chi-square test on the basis of class frequency ratio of 1:1.

For criterion of directionality we used $p<0.01$ significance level at percentage probability of undirectionality calculated by maximum likelihood estimation.

Fig. 2. shows the relationships between percentage probability of undirectionality and chi-square values of significant differences. Regarding the critical values of chi-square test the chosen 1% probability value falls between $0.025>p>0.01$ significance levels. Only the values less then this limit were regarded as significant directionality. This range was divided into 3 tracks for further refinement of significance levels (see fig. 6. A—B and fig. 8. A—B).

Results

On the basis of results of provisory collections the distribution of *Auchenorrhyncha* individuals in 0—50, 50—100 and 100—150 cm strata was 84.8%, 8.2% and 7.0%, respectively. This was calculated from 1696 individuals collected in 1981. In 1982 the distribution of 13895 collected imagos in the 0—50 and 50—100

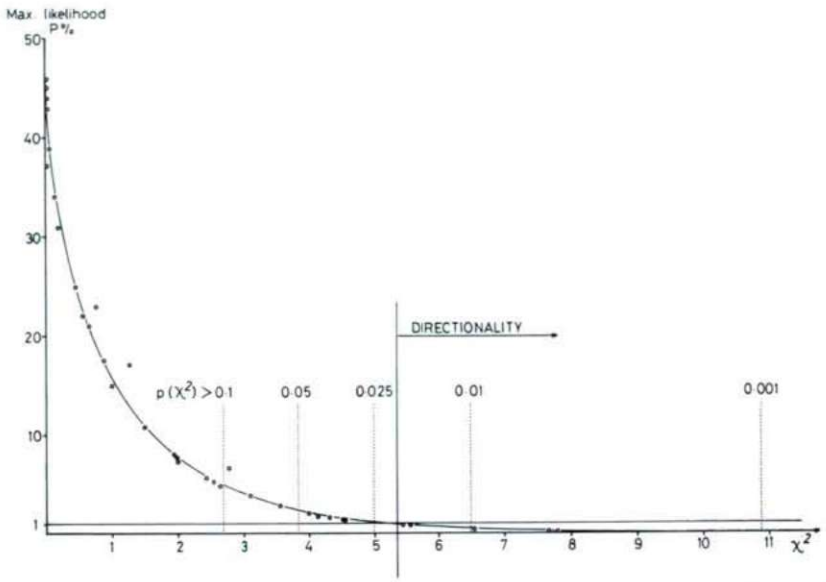

Fig. 2. Relationship between probability values (P%) of undirectionality calculated with maximum likelihood method and chi-square values of significant difference. Dotted lines sign significance levels of chi-square test.

cm strata was: 84% and 16%, respectively. Individuals of only 8 species occurred exclusively in one of the upper dishes, 16 specimens all. In the case of *Acridoidea* only 3.9% of all individuals occurred in the upper dishes.

Above results and larger scale stratification-examinations from WALOFF (1984), WEBER and WILSON (1981) and GÜNTHART (1988) show that the movement activity of insects in the grass or herb layer is best observable in the 0—50 cm stratum. In the followings we shall consider the material of these traps only.

I. TURNOVER OF INDIVIDUALS IN THE BOUNDARY ZONES

1. *Qualitative and quantitative distribution according to the directions of traps*

In both experimental year (1982—83) 41689 *Auchenorrhyncha* individuals and 12966 *Acridoidea* imagos were collected. In addition the number of grasshopper nymphs is signed (though probably the efficiency of traps is less in this case), since their movement directionality was very similar to that of adults. The individual number of nymphs was not more then 882. Tables 1—4. of Appendix show the species composition of collected material and the sex ratio of imagos.

We found 118 *Auchenorrhynca* species altogether in the collected material. The largest species number was recorded at the forest side in both years (108 and 113), while at the pasture side individuals of 95 and 88 species were collected, respectively.

Table 1. Individual number of species collected in 1982. *(Auchenorrhyncha)*

Species	1982							
	Forest		Plot		Pasture		Plot	
	♂	♀	♂	♀	♂	♀	♂	♀
CICADELLIDAE								
Aconurella quadrum H. S.	1	—	—	—	—	—	—	—
Agallia laevis RIB.	7	3	6	2	31	3	11	1
Allygus atomarius FABR.	—	—	1	—	—	—	—	—
Allygus commutatus FIEB.	—	1	—	1	—	—	—	—
Allygus mixtus FABR.	—	1	—	—	—	—	—	—
Anaceratagallia ribauti OSS.	6	4	6	3	9	4	11	3
Anoscopus albiger GERM.	—	—	—	—	—	—	—	—
Anoscopus histrionicus FABR.	—	1	1	—	—	—	—	—
Anoscopus serratulae FABR.	—	—	—	—	—	—	—	—
Aphrodes bicinctus SCHR.	1	1	—	—	23	3	21	5
Arboridia parvula BOH.	8	2	2	1	7	2	1	5
Arocephalus lanquidus FLOR.	3	2	1	1	5	6	3	3
Arthaldeus pascuellus FALL.	—	—	1	—	—	—	—	—
Arthaldeus striifrons KIRSCHB.	1	—	1	—	1	—	1	—
Artianus interstitialis GERM.	28	10	23	9	17	6	26	6
Athysanus argentarius METC.	1	1	1	—	—	—	—	1
Austroagallia sinuata M. R.	12	12	38	14	12	4	12	5
Balclutha rhenana WAGN.	1	—	1	—	—	—	1	1
Batracomorphus irroratus LEW.	2	2	1	1	3	2	7	8
Bobacella corvina HORV.	182	67	104	75	77	30	102	54
Chlorita dumosa RIB.	30	5	20	13	64	42	66	39
Chlorita hungarica RIB.	—	—	—	—	—	—	—	—
Chlorita paolii OSS.	29	10	7	4	30	10	17	7
Cicadella viridis L.	2	—	1	—	1	1	—	1
Cicadula quadrinotata FABR.	—	1	—	1	—	—	1	1
Deltocephalus pulicaris FALL.	1	1	—	—	—	—	1	—
Dikraneura similis EDW.	—	—	—	—	1	—	—	—
Doratura exilis HORV.	6	1	5	3	8	1	10	2
Doratura heterophyla HORV.	5	2	3	1	20	1	18	1
Doratura homophyla FLOR.	51	23	31	26	163	39	132	18
Doratura impudica HORV.	1	—	—	—	—	—	—	—
Doratura stylata BOH.	42	11	48	9	45	25	47	16
Dryodurgades dlabolai WAGN.	2	3	2	—	—	1	—	3
Edwardsiana candidula KIRSCHB.	9	—	10	3	4	—	2	—
Edwardsiana rosae L.	—	—	—	—	—	1	—	—
Emelyanoviana mollicula BOH.	25	15	27	29	8	9	6	3
Errastunus notatifrons KIRSCHB	—	—	—	—	1	—	—	—
Erythroneura discolor HORV.	1	—	1	—	—	—	—	1
Eupelix cuspidata FABR.	20	4	26	3	26	6	14	2
Eupteryx aurata L.	4	7	5	8	9	15	4	8
Eupteryx collina FLOR.	—	—	—	—	—	—	1	—
Eupteryx notata CURT.	10	2	7	2	16	4	20	7
Eupteryx stachydearum HARDY	6	9	3	4	2	3	2	3
Eupteryx thoulessi EDW.	26	18	11	10	3	4	6	5
Euscelidius schenckii KIRSCHB.	—	—	—	1	1	—	1	—
Euscelis incisus KIRSCHB.	24	9	19	6	58	15	48	13
Goniagnathus brevis H. S.	11	4	8	4	31	5	19	5

Graphocraerus ventralis FALL.	13	4	7	1	14	5	16	4
Handianus ignoscus MEL.	—	—	—	—	—	—	—	—
Hardyopsis insularis LINDB.	1	3	3	2	—	1	—	2
Hecalus glaucescens FIEB.	47	8	87	7	293	21	109	20
Idiocerus albicans KIRSCHB.	1	—	2	1	—	2	—	—
Idiocerus decimusquartus SCHRK.	—	—	—	1	—	—	—	—
Idiocerus distinquendus KIRSCHB.	1	—	—	—	2	—	—	—
Idiocerus humilis HORV.	—	—	1	—	—	—	1	—
Idiocerus populi L.	5	4	14	12	1	2	1	1
Jassargus obtusivalvis KIRSCHB.	10	5	7	2	1	—	1	—
Jassargus sursumflexus THEN.	—	9	1	3	—	2	1	1
Kybos abstrusa LINN.	25	—	12	—	4	—	5	—
Limotettix striola FALL.	—	—	—	—	1	—	—	—
Limotettix transversus FALL.	—	—	1	—	—	—	—	—
Macropsis impura BOH.	2	—	2	—	—	—	—	—
Macropsis vicina HORV.	2	—	—	—	—	—	—	—
Macrosteles laevis RIB.	—	1	1	—	—	—	1	—
Macrosteles quadripunctulatus KIRSCHB.	1	—	—	—	—	—	—	—
Macustus grisescens ZETT.	222	79	118	54	40	16	32	20
Megophtalmus scanicus FALL.	—	—	1	—	—	—	1	—
Mendrausus pauxillus FIEB.	161	31	103	30	263	39	237	37
Micantulina stigmatipennis M. R.	47	15	47	19	238	157	186	109
Mocuellus collinus BOH.	—	—	—	—	1	1	—	—
Mocuellus metrius FLOR.	—	—	—	—	—	—	1	—
Mocydia crocea H. S.	1	1	—	—	—	—	—	—
Mocydiopsis attenuata GERM.	—	—	—	—	—	—	—	—
Mocydiopsis parvicauda RIB.	—	1	2	—	—	1	—	—
Neoaliturus fenestratus H. S.	7	13	9	8	9	10	11	9
Neoaliturus haematoceps M. R.	2	2	—	1	11	6	12	3
Oncopsis sp.	—	—	—	—	—	—	—	—
Paluda preyssleri H. S.	1	—	4	—	—	1	1	1
Paluda vitripennis FLOR.	60	16	62	27	97	40	65	43
Paralimnus phragmitis BOH.	—	1	—	—	—	—	—	—
Paramesus obtusifrons STAL	—	2	—	—	—	—	—	—
Penthimia nigra GOEZE	—	—	1	—	—	—	—	1
Planaphrodes elongatus LETH.	77	33	89	50	68	28	112	41
Platymetopius major KIRSCHB.	—	1	—	—	—	—	—	—
Platymetopius undatus DE GEER	—	—	—	—	—	—	—	1
Psammotettix alienus DHLB.	5	—	5	1	11	3	8	4
Psammotettix confinis DHLB.	13	5	20	8	30	13	31	15
Psammotettix hungaricus OROSZ	1	1	—	—	—	—	—	—
Psammotettix pallidinervis DHLB.	8	5	12	4	3	—	5	—
Psammotettix provincialis RIB.	369	253	269	229	544	413	522	367
Psammotettix slovacus DLAB.	2	3	1	—	1	1	1	1
Recilia schmidtgeni WAGN.	276	24	234	18	711	27	596	45
Speudotettix subfusculus FALL.	3	—	—	—	—	2	—	—
Streptanus aemulans KIRSCHB.	—	—	—	—	—	1	—	—
Sroggylocephalus livens ZETT.	—	—	—	—	—	—	—	—
Tetartostylus pellucidus WAGN.	—	—	1	1	—	1	—	—
Turrutus socialis FLOR.	295	100	165	84	510	152	538	165
Ulopa lugens GERM.	—	—	—	—	—	—	—	—
Ulopa trivia GERM.	10	4	5	1	4	2	4	1
Zygina lunaris M. R.	10	11	20	10	1	2	1	2

Zygina nivea M. R.	—	—	—	—	—	—	—	—
Zygina tithide FERR.	—	5	1	3	—	—	—	—
Zyginidia pullula BOH.	100	41	67	40	112	94	91	56
DELPHACIDAE								
Delphacodes albifrons FIEB.	—	—	1	—	—	—	—	—
Dicranotropis hamata BOH.	—	—	—	—	—	—	—	—
Ditropsis flavipes SIGN.	—	—	—	—	1	—	—	—
Euconomelus lepidus BOH.	—	1	—	—	1	—	—	—
Eurybregma nigrolineata SCOTT	—	—	—	—	—	—	1	—
Eurysula lurida FIEB.	1	5	1	6	1	5	—	3
Falcotoya minuscula HORV.	37	74	45	50	46	66	46	83
Gravesteiniella boldi SCOTT	74	78	77	83	16	12	26	30
Hyledelphax elegantulus BOH.	1	—	—	—	—	—	—	—
Jassidaeus lugubris SIGN.	19	13	11	8	5	2	21	25
Javesella dubia KIRSCHB.	—	—	—	—	—	—	—	—
Javesella pellucida FABR.	1	3	3	2	2	2	—	3
Kelisia brucki FIEB.	—	—	—	1	—	—	1	—
Kelisia monoceros RIB.	2	—	1	—	—	—	—	—
Kelisia pallidula BOH.	1	—	—	—	1	—	—	—
Kelisia perrieri RIB.	—	—	—	—	—	3	—	—
Kelisia ribauti WAGN.	—	—	—	—	—	—	—	—
Kosswigianella exiqua BOH.	3	15	24	19	—	1	—	—
Megadelphax sordidulus STAL	—	—	—	—	—	—	—	—
Metadelphax propinqua FIEB.	2	5	4	5	3	9	5	12
Muellerianella fairmairei PERR.	2	—	1	1	1	—	—	—
Muirodelphax aubei PERR.	1	—	—	—	—	—	—	—
Ribautodelphax albostriata FIEB.	4	—	—	1	—	—	—	1
Ribautodelphax imitans RIB.	—	—	1	—	—	—	—	—
Stenocranus minutus FABR.	—	—	—	—	—	—	—	—
Struebingianella palliceps HORV.	—	—	—	—	—	—	—	—
Weidnerianella marginata FALL.	17	11	26	22	12	9	17	11
Xanthodelphax straminea STAL	—	—	—	—	—	—	1	1
TETTIGOMETRIDAE								
Tettigometra atra HGBACH.	—	—	—	—	—	—	—	—
Tettigometra concolor FIEB.	1	—	—	—	—	—	—	—
Tettigometra suphurea M. R.	1	—	1	—	—	—	—	—
CERCOPIDAE								
Aphrophora alni FALL.	—	3	—	—	—	—	—	—
Aphrophora salicina GOEZE	1	—	—	—	—	—	—	—
Lepyronia coleoptrata L.	26	20	15	21	22	11	25	11
Neophilaenus campestris FALL.	8	10	3	4	25	21	13	22
Neophilaenus lineatus L.	4	2	1	2	—	—	—	—
Neophilaenus minor KIRSCHB.	—	—	—	—	—	1	—	1
Philaenus spumarius L.	9	12	6	9	8	4	16	15
TROPIDUCHIDAE								
Trypetimorpha fenestrata COSTA	4	3	4	1	1	1	2	1
ISSIDAE								
Ommatidiotus dissimilis FALL.	48	28	39	28	14	17	23	14

ACHILIDAE								
Cixidia marginicollis SPIN.	—	—	—	—	1	—	—	—
MEMBRACIDAE								
Stictocephala bisonia K. Y.	—	—	—	—	—	—	—	—
CIXIIDAE								
Pentastiridius leporinus L.	—	—	—	2	2	1	1	—
DICTYOPHARIDAE								
Chanithus pannonicus GERM.	—	—	—	—	—	—	1	—
Total	2603	1196	2059	1115	3809	1449	3400	1409

Table 2. Individual number of species collected in 1983. *(Auchenorrhyncha)*
1983

Species	Forest		Plot		Pasture		Plot	
	♂	♀	♂	♀	♂	♀	♂	♀
CICADELLIDAE								
Aconurella quadrum H. S.	—	—	1	—	—	—	—	—
Agallia laevis RIB.	63	23	108	18	139	14	67	18
Allygus atomarius FABR.	—	—	—	—	—	—	—	—
Allygus commutatus FIEB.	—	—	—	1	—	—	—	—
Allygus mixtus FABR.	—	—	—	—	—	—	—	—
Anaceratagallia ribauti OSS.	30	—	46	1	35	5	17	3
Anoscopus albiger GERM.	1	—	—	—	—	—	—	—
Anoscopus histrionicus FABR.	1	—	—	—	—	—	—	—
Anoscopus serratulae FABR.	1	—	—	—	1	—	—	—
Aphrodes bicinctus SCHR.	—	2	—	1	2	2	3	1
Arboridia parvula BOH.	—	1	2	1	1	1	2	—
Arocephalus lanquidus FLOR.	28	15	17	10	9	7	3	4
Arthaldeus pascuellus FALL.	—	—	—	—	—	—	—	—
Arthaldeus striifrons KIRSCHB.	2	—	1	—	—	—	1	1
Artianus interstitialis GERM.	30	22	36	10	64	11	34	16
Athysanus argentarius METC.	—	—	—	—	—	—	—	—
Austroagallia sinuata M. R.	19	57	105	66	35	29	25	20
Balclutha rhenana WAGN.	—	—	—	—	—	1	—	—
Batracomorphus irroratus LEW.	1	1	—	1	10	9	4	8
Bobacella corvina HORV.	114	82	94	119	66	39	62	60
Chlorita dumosa RIB.	77	24	36	22	59	25	51	13
Chlorita hungarica RIB.	—	—	—	—	—	1	—	—
Chlorita paolii OSS.	318	18	152	15	93	20	92	19
Cicadella viridis L.	1	—	—	1	—	—	—	—
Cicadula quadrinotata FABR.	—	—	—	—	—	—	—	—
Deltocephalus pulicaris FALL.	4	8	1	4	3	7	1	6
Dikraneura similis EDW.	1	—	—	—	1	—	1	—
Doratura exilis HORV.	4	—	—	—	—	—	—	—
Doratura heterophyla HORV.	5	3	4	1	—	1	—	—
Doratura homophyla FLOR.	17	13	17	17	248	53	226	56
Doratura impudica HORV.	3	1	5	3	—	—	—	—

Doratura stylata BOH.	76	17	62	16	57	17	46	14
Dryodurgades dlabolai WAGN.	1	3	—	2	1	2	1	—
Edwardsiana candidula KIRSCHB.	5	1	2	1	—	—	1	—
Edwardsiana rosae L.	—	—	—	—	—	—	—	—
Emelyanoviana mollicula BOH.	71	30	50	26	5	5	8	4
Errastunus notatifrons KIRSCHB	1	—	1	—	—	—	—	—
Erythroneura discolor HORV.	—	—	—	—	—	—	—	—
Eupelix cuspidata FABR.	50	4	65	17	53	6	67	10
Eupteryx aurata L.	8	3	5	2	1	4	—	5
Eupteryx collina FLOR.	—	—	—	—	—	—	1	—
Eupteryx notata CURT.	72	9	27	2	31	6	23	8
Eupteryx stachydearum HARDY	—	2	1	1	1	—	1	—
Eupteryx thoulessi EDW.	20	15	9	15	4	8	4	3
Euscelidius schenckii KIRSCHB.	—	—	—	—	—	—	—	—
Euscelis incisus KIRSCHB.	15	8	12	5	78	20	67	7
Goniagnathus brevis H. S.	46	6	40	7	69	11	69	5
Graphocraerus ventralis FALL.	13	1	7	5	12	4	12	6
Handianus ignoscus MEL.	—	—	1	—	1	—	—	—
Hardyopsis insularis LINDB.	—	—	1	1	—	—	—	1
Hecalus glaucescens FIEB.	115	23	92	20	398	31	320	34
Idiocerus albicans KIRSCHB.	—	—	—	—	—	—	—	—
Idiocerus decimusquartus SCHRK.	—	1	1	—	—	—	—	1
Idiocerus distinquendus KIRSCHB.	—	—	—	—	—	—	—	—
Idiocerus humilis HORV.	—	—	—	—	—	—	—	—
Idiocerus populi L.	7	5	2	—	2	4	2	4
Jassargus obtusivalvis KIRSCHB.	18	15	18	7	2	—	1	1
Jassargus sursumflexus THEN.	—	—	—	5	—	—	—	—
Kybos abstrusa LINN.	22	1	14	3	5	—	5	—
Limotettix striola FALL.	—	—	—	—	—	—	—	—
Limotettix transversus FALL.	—	—	—	—	—	—	—	—
Macropsis impura BOH.	1	2	—	—	—	—	—	—
Macropsis vicina HORV.	—	—	—	—	—	—	—	—
Macrosteles laevis RIB.	7	16	4	11	—	5	1	1
Macrosteles quadripunctulatus KIRSCHB.	1	1	—	1	—	—	—	—
Macustus grisescens ZETT.	88	31	83	37	12	9	13	4
Megophtalmus scanicus FALL.	—	—	—	—	—	—	—	—
Mendrausus pauxillus FIEB.	100	25	164	26	106	27	95	16
Micantulina stigmatipennis M. R.	14	5	23	6	20	14	29	21
Mocuellus collinus BOH.	—	3	2	2	1	—	—	1
Mocuellus metrius FLOR.	—	—	—	—	—	—	—	—
Mocydia crocea H. S.	2	2	5	1	—	—	—	—
Mocydiopsis attenuata GERM.	1	—	—	—	—	—	—	—
Mocydiopsis parvicauda RIB.	—	—	1	—	—	—	—	—
Neoaliturus fenestratus H. S.	42	16	40	7	16	20	12	5
Neoaliturus haematoceps M. R.	4	—	—	3	5	3	8	8
Oncopsis sp.	—	2	1	2	—	4	1	1
Paluda preyssleri H. S.	6	—	7	1	1	—	—	—
Paluda vitripennis FLOR.	41	13	85	32	52	24	37	13
Paralimnus phragmitis BOH.	—	—	—	—	—	—	—	—
Paramesus obtusifrons STAL	—	—	—	—	—	—	—	—
Penthimia nigra GOEZE	—	—	—	—	—	—	—	—
Planaphrodes elongatus LETH.	8	12	18	15	10	8	3	11
Platymetopius major KIRSCHB.	1	—	—	—	—	—	—	—

Platymetopius undatus DE GEER	—	—	—	—	—	—	1	—
Psammotettix alienus DHLB.	13	7	9	2	7	2	7	5
Psammotettix confinis DHLB.	31	14	21	9	49	18	27	13
Psammotettix hungaricus OROSZ	—	—	—	—	—	—	—	—
Psammotettix pallidinervis DHLB.	24	10	22	11	25	10	31	16
Psammotettix provincialis RIB.	710	703	656	609	689	690	580	556
Psammotettix slovacus DLAB.	13	6	14	6	4	3	4	5
Recilia schmidtgeni WAGN.	561	96	368	61	1416	81	1392	113
Speudotettix subfusculus FALL.	2	—	—	—	—	—	—	—
Streptanus aemulans KIRSCHB.	—	—	—	—	—	—	—	—
Sroggylocephalus livens ZETT.	—	2	—	2	1	1	—	1
Tetartostylus pellucidus WAGN.	—	—	—	—	—	—	—	—
Turrutus socialis FLOR.	251	63	241	61	162	35	192	30
Ulopa lugens GERM.	1	—	1	—	—	—	—	—
Ulopa trivia GERM.	43	1	32	—	27	—	20	3
Zygina lunaris M. R.	—	—	—	—	—	—	—	—
Zygina nivea M. R.	2	—	1	—	1	—	—	—
Zygina tithide FERR.	—	—	—	—	—	—	—	—
Zyginidia pullula BOH.	187	96	125	142	95	46	55	55
DELPHACIDAE								
Delphacodes albifrons FIEB.	—	—	—	—	—	—	—	—
Dicranotropis hamata BOH.	—	—	1	—	—	—	—	—
Ditropsis flavipes SIGN.	1	—	—	—	—	—	—	—
Euconomelus lepidus BOH.	2	—	—	—	—	—	—	1
Eurybregma nigrolineata SCOTT	1	—	—	—	—	—	—	—
Eurysula lurida FIEB.	2	7	1	5	—	3	2	4
Falcotoya minuscula HORV.	271	326	333	346	668	601	422	476
Gravesteiniella boldi SCOTT	97	108	118	122	8	16	9	14
Hyledelphax elegantulus BOH.	1	—	1	—	—	—	—	—
Jassidaeus lugubris SIGN.	5	6	3	4	—	2	2	3
Javesella dubia KIRSCHB.	1	1	—	—	—	—	—	—
Javesella pellucida FABR.	1	1	—	—	—	2	—	—
Kelisia brucki FIEB.	—	1	—	1	3	—	1	2
Kelisia monoceros RIB.	—	—	2	1	1	2	—	—
Kelisia pallidula BOH.	—	—	1	—	—	—	1	—
Kelisia perrieri RIB.	—	1	—	—	—	—	—	—
Kelisia ribauti WAGN.	1	—	—	—	—	—	1	1
Kosswigianella exiqua BOH.	6	9	4	6	6	10	8	6
Megadelphax sordidulus STAL	1	—	—	—	—	—	—	—
Metadelphax propinqua FIEB.	8	3	2	3	5	12	5	5
Muellerianella fairmairei PERR.	—	—	—	—	—	—	—	—
Muirodelphax aubei PERR.	1	—	—	—	—	—	—	—
Ribautodelphax albostriata FIEB.	2	2	3	—	—	—	1	—
Ribautodelphax imitans RIB.	1	1	—	—	1	—	—	—
Stenocranus minutus FABR.	1	—	—	—	—	—	—	—
Struebingianella palliceps HORV.	14	5	11	8	—	1	—	—
Weidnerianella marginata FALL.	3	10	1	5	3	1	5	5
Xanthodelphax straminea STAL	—	—	—	—	—	—	—	—
TETTIGOMETRIDAE								
Tettigometra atra HGBACH.	1	—	—	—	—	—	—	—
Tettigometra concolor FIEB.	—	—	—	—	—	—	—	—
Tettigometra suphurea M. R.	1	—	1	—	1	—	—	—

CERCOPIDAE								
Aphrophora alni FALL.	—	—	—	—	—	—	—	—
Aphrophora salicina GOEZE	—	—	—	—	—	—	—	—
Lepyronia coleoptrata L.	25	23	34	14	33	19	31	29
Neophilaenus campestris FALL.	14	15	12	14	19	29	27	20
Neophilaenus lineatus L.	1	1	3	4	2	1	1	—
Neophilaenus minor KIRSCHB.	—	—	1	1	—	—	—	—
Philaenus spumarius L.	4	8	7	13	3	3	3	3
TROPIDUCHIDAE								
Trypetimorpha fenestrata COSTA	16	5	5	2	1	1	1	—
ISSIDAE								
Ommatidiotus dissimilis FALL.	27	21	16	22	16	12	22	16
ACHILIDAE								
Cixidia marginicollis SPIN.	1	1	3	—	—	—	1	1
MEMBRACIDAE								
Stictocephala bisonia K. Y.	—	1	—	—	—	—	—	—
CIXIIDAE								
Pentastiridius leporinus L.	—	—	—	1	2	1	1	1
DICTYOPHARIDAE								
Chanithus pannonicus GERM.	1	—	1	—	2	—	1	—
Total	3925	2096	3522	2045	4959	2059	4270	1793

Table 3. Individual number of species collected in 1982. *(Acridoidea)*

Species	1982							
	Forest		Plot		Pasture		Plot	
	♂	♀	♂	♀	♂	♀	♂	♀
CATANTOPIDAE								
Calliptamus italicus L.	6	2	1	1	24	11	31	14
Calliptamus barbarus COSTA	3	1	3	3	9	9	10	9
Nymphs:	5		3		19		7	
ACRIDIDAE								
Oedaleus decorus GER.	—	—	—	—	—	—	2	1
Nymphs:	—		—		2		—	
Oedipoda coerulescens L.	—	1	—	2	3	2	1	2
Nymphs:	—		1		2		1	
Dociostaurus brevicollis EVER.	22	11	16	6	11	8	12	8
Nymphs:	2		—		—		—	
Stenobothrus (S.) crassipes CHARP.	44	15	56	19	93	26	30	10
Stenobothrus (S.) fischeri EVER.	18	13	13	11	8	9	13	4

Stenobothrus (S.) nigromaculatus H. S.	10	10	16	15	13	11	20	20
Nymphs:	2		11		—		—	
Omocestus (O.) ventralis ZETT.	2	—	1	1	3	—	—	1
Omocestus (D.) haemorrhoidalis CHARP.	6	—	10	—	31	7	25	11
Nymphs:	—		—		—		—	
Omocestus (D.) petraeus BRIS.	4	4	3	2	9	3	7	3
Myrmeleotettix antennatus FIEB.	5	2	1	1	1	—	1	—
Myrmeleotettix maculatus THUNBG.	—	2	—	1	—	3	—	—
Nymphs:	—		—		—		—	
Chorthippus (G.) brunneus THUNBG.	9	1	11	4	24	6	12	2
Chorthippus (G.) mollis CHARP.	24	4	11	4	18	3	10	—
Chorthippus (Ch.) dichrous EVER.	2	1	7	1	7	6	6	3
Chorthippus (Ch.) dorsatus ZETT.	10	6	2	4	13	9	8	7
Chorthippus (Ch.) longicornis LATR.	28	16	27	16	60	19	25	11
Nymphs:	—		2		—		—	
Euchorthippus pulvinatus F. W.	65	17	58	16	27	13	34	12
Euchorthippus declivus BRIS.	469	111	661	113	523	202	233	140
Nymphs:	9		1		4		3	
Total (adult)	727	217	897	220	877	347	480	258
Total (adult + nymph)	962		1135		1251		749	

Table 4. Individual number of species collected in 1983. *(Acridoidea)*

Species	1983							
	Forest		Plot		Pasture		Plot	
	♂	♀	♂	♀	♂	♀	♂	♀
CATANTOPIDAE								
Calliptamus italicus L.	22	1	13	4	26	8	15	7
Calliptamus barbarus COSTA	2	1	—	1	4	3	1	2
Nymphs:	37		22		129		76	
ACRIDIDAE								
Oedaleus decorus GER.	1	—	2	—	—	—	1	—
Nymphs:	7		—		1		4	
Oedipoda coerulescens L.	3	2	4	—	—	—	1	1
Nymphs:	12		5		3		14	
Dociostaurus brevicollis EVER.	33	8	13	10	29	18	14	4
Nymphs:	2		2		—		—	
Stenobothrus (S.) crassipes CHARP.	66	2	66	3	92	27	34	4
Stenobothrus (S.) fischeri EVER.	24	25	14	26	34	32	30	44
Stenobothrus (S.) nigromaculatus H. S.	36	6	36	14	57	18	39	18
Nymphs:	14		7		5		13	
Omocestus (O.) ventralis ZETT.	—	—	—	—	—	—	—	—
Omocestus (D.) haemorrhoidalis CHARP.	12	—	11	2	21	2	11	2
Nymphs:	—		—		5		8	
Omocestus (D.) petraeus BRIS.	5	3	3	—	12	2	4	1
Myrmeleotettix antennatus FIEB.	—	—	3	—	—	—	—	—

Myrmeleotettix maculatus THUNBG.	1	—	—	—	1	1	—	—
Nymphs:	1		—		—		—	
Chorthippus (G.) brunneus THUNBG.	16	5	21	7	10	8	5	3
Chorthippus (G.) mollis CHARP.	32	7	30	7	18	3	15	3
Chorthippus (Ch.) dichrous EVER.	4	2	—	1	5	8	3	—
Chorthippus (Ch.) dorsatus ZETT.	3	—	4	2	14	8	11	2
Chorthippus (Ch.) longicornis LATR.	88	56	170	105	213	140	88	39
Nymphs:	23		30		20		28	
Euchorthippus pulvinatus F. W.	32	6	41	13	18	10	12	11
Euchorthippus declivus BRIS.	1144	218	1726	287	1820	563	550	238
Nymphs:	43		48		72		177	
Total (adult)	1524	342	2157	482	2374	851	834	379
Total (adult + nymph)	2005		2753		3460		1533	

At the forest side larger difference was measured in the number of species arriving from the two directions — number of entering species was 98 and 102, that of leaving ones was 87 and 91, respectively. At pasture side there was not considerable difference between the two directions. Here the number of entering species was 82 and 77, that of leaving ones was 80 and 76, respectively.

Quantitatively the movements to the direction of ungrazed area dominated in both boundary zones. The number of individuals from the forest exceeded that of emigrants by 19.8% (1982) and 8.2% (1983), and that from the pasture by 9.3% and 15.6%, respectively. Number of males was about 2.5 times larger than that of females in the distribution of individuals moving at the pasture side, but at the forest side we caught only about 1.9 times more males.

In totality the individual turnover was greater at the pasture side in both years, in 1982 it was greater about 1.5 times, and in 1983 1.13 times as high as that of forest side.

Species number of grasshoppers did not alter neither in respect of the two boundary zones, nor within them between the two directions. Species number was 20 everywhere with minimal replacement. Quantitatively we measured large inprush at the pasture side and lighter outprush at the forest side in both years. Traps collected more individuals by 65.8% (1982) and by 165.9% (1983) from the direction of pasture than from the ungrazed area. At the same time the number of individuals moving to the direction of forest was greater by 18.3% and 41.4%, respectively, than to the opposite direction. We found much more males than females (4x) among individuals moving at the forest side (in contradistinction to *Auchenorrhyncha*), but at the pasture side only 2.3 times more males were caught. The intensity of individual turnover within the boundary zones is almost same in the two years.

2. *Seasonal alteration of movement activity*

To study the temporal appearance and quality of general seasonal tendency, we calculated the catching quantities per day for each collecting period. So we obtained comparable data that can be seen at Fig. 3. and 4.

Auchenorrhyncha have maximal activity in May—June in both boundary zone in both year (Fig. 3.). This may be followed by a much lighter increase in August (this vas wery large at pasture in 1983), or in September—October (in the case of the forest in 1982).

At the forest side the surplus which directed to the experimental area appeared in the activity maximum. At the pasture side the entering surplus could be registered only in midsummer and in October, but not steady tendency was found in the other periods in respect of catching direction.

Very high peak of activity was measured in July in the movement of grasshoppers, that lasted in the beginning of August (Fig. 4.). Also a smaller peak

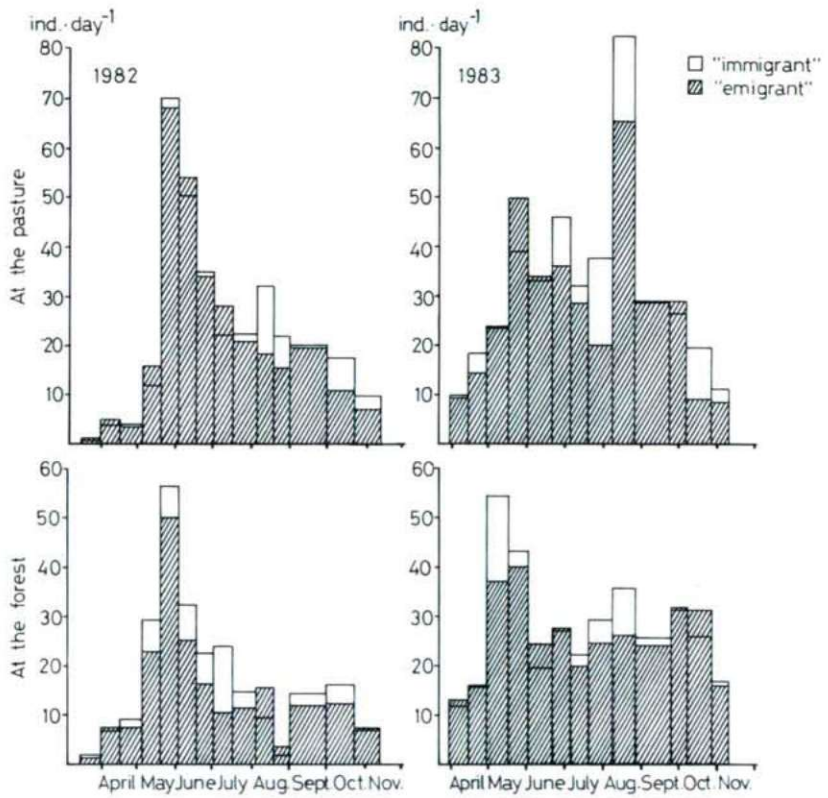

Fig. 3. Seasonal changes of individual number of *Auchenorrhyncha* imagos per day in both years, from data summed up according to trap directions.

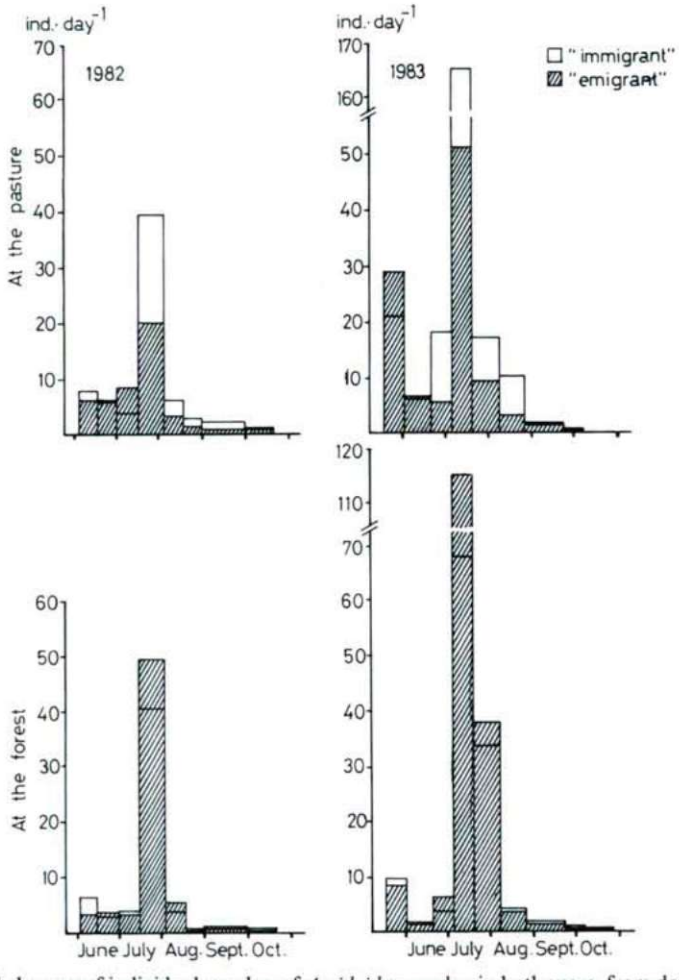

Fig. 4. Seasonal changes of individual number of *Acridoidea* per day in both years, from data summed up according to trap directions.

formed in May 1983 that was caused by larvae. (Data of the figures contain also larvae in the case of this group.)

Definite and consequent trend can be seen in the number of animals arriving from different directions after development and becoming dominant of imagos. This may be promoted by small species number. Continuous inrush could be measured at the pasture side until September, intensity of which was the largest at activity maximum. The outrush at the forest side was not so lasting and intensive.

II. ESTIMATION OF MOVEMENT DIRECTIONALITY

In the course of evaluation of global data different trends of several populations may conceal, suppress each other, mainly in case of the *Auchenorrhyncha* community with large species number. That is why we examined the populations of dominant species one by one. Generations or subpopulations may behave in different manner. To determine activity periods we examined the seasonal percentage distribution of important species in the collected material (Fig. 5.A—C). The populations were divided into subpopulations on this basis. The place of division is marked by arrow at the connected activity curves.

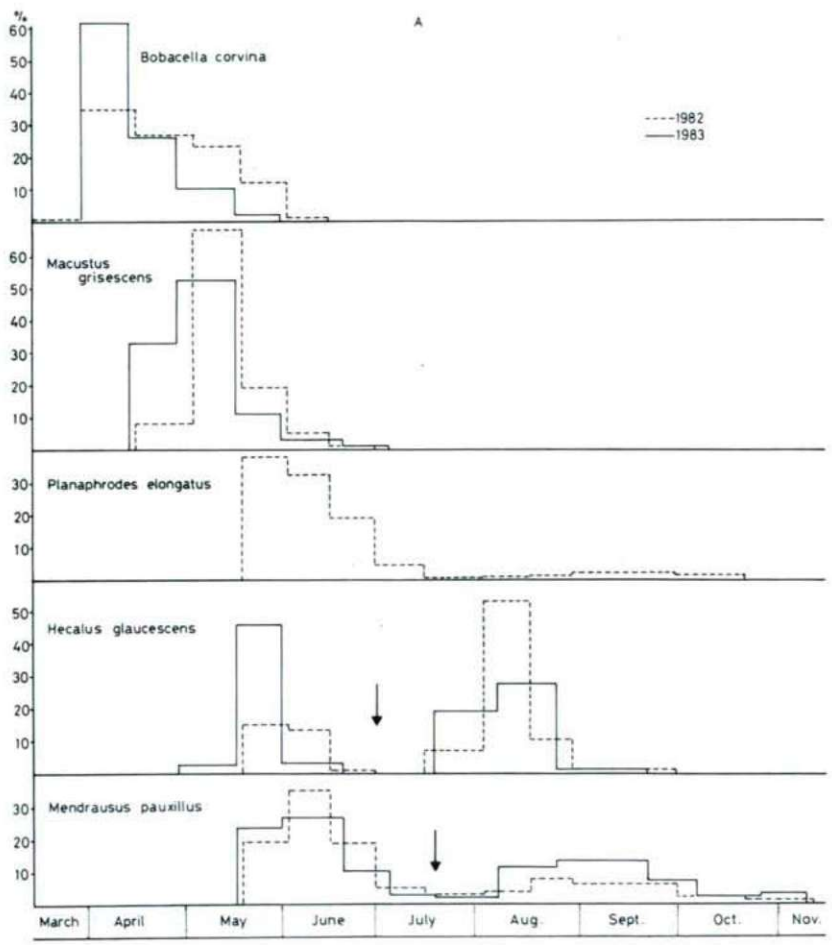

Fig. 5.A) Seasonal distribution of dominant *Auchenorrhyncha* species. (Arrows indicate the division of subpopulations.)

Thus the movement directionality was calculated separately for the distinguished periods. The summarized results are shown by Fig. 6.A—B. Quantitatively the inrush predominated at both side in case of *Auchenorrhyncha*, number of species moving significantly to the direction of pasture was 6, that of species moving to the direction of forest was 7. At the same time 10 species entered the sampling area from the pasture and 7 from the forest.

It seems from the joint evaluation of two kinds of figures, that three activity periods distinguished in the case of *Auchenorrhyncha*. These are March—May, June—August and September—October.

In the spring aspect the outrush predominated at the pasture side (*Bobacella corvina, Planaphrodes elongatus, Hecalus glaucescens, Psammotettix provincialis* and *Recilia schmidtgeni*), while at the forest side the inrush was dominant (*Bobacella corvina, Macustus grisescens, Zyginidia pullula, Chlorita paolii, Psammotettix*

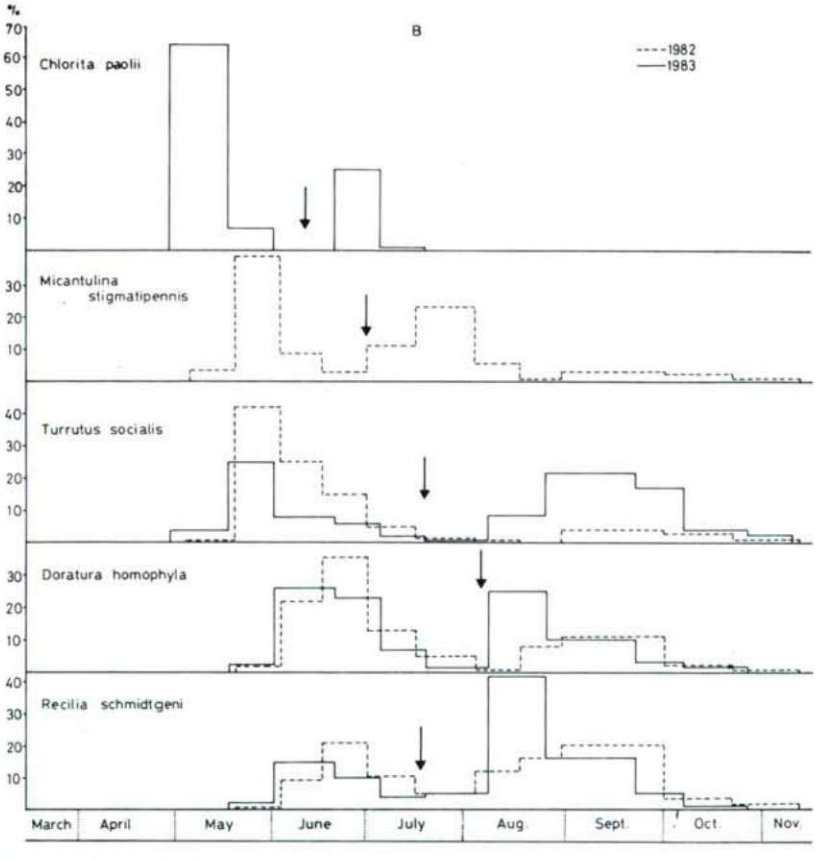

Fig. 5.B) Seasonal distribution of dominant *Auchenorrhyncha* species. (Arrows indicate the division of subpopulations.)

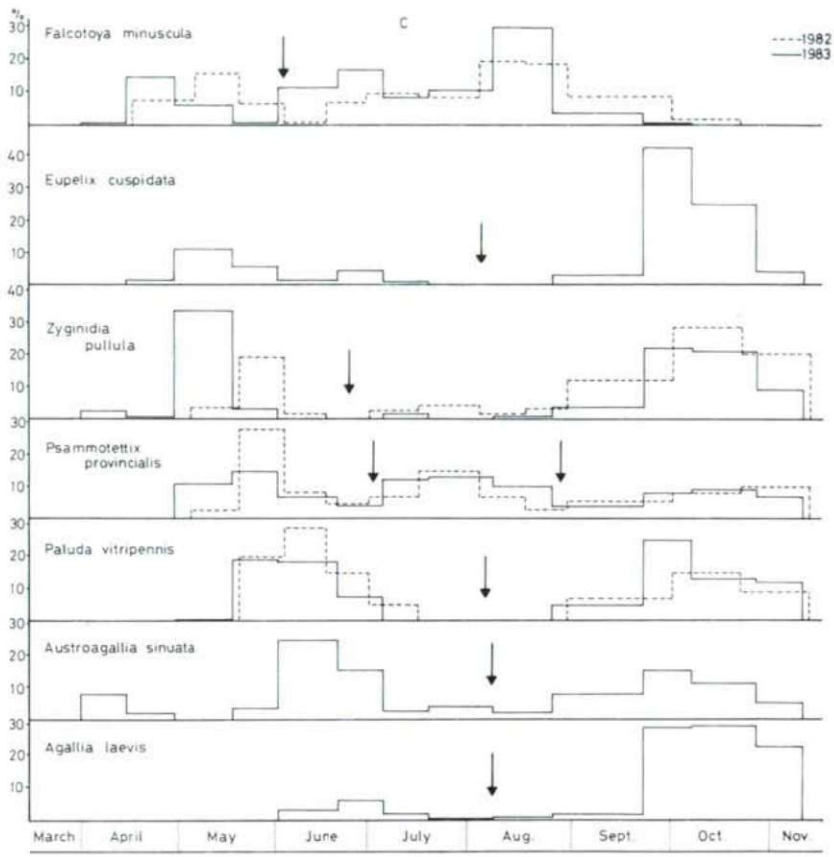

Fig. 5.C) Seasonal distribution of dominant *Auchenorrhyncha* speices. (Arrows indicate the division of subpopulations.)

provincialis, Turrutus socialis, Recilia schmidtgeni). This trend directing to the pasture turned over in the summer months. The movement activity decreased in the warmest period of July. The attractive effect of the experimental area increased that can be measured on the inrush from the pasture in case of *Falcotoya minuscula, Paluda vitripennis, Micantulina stigmatipennis, Doratura homophyla, Psammotettix provincialis, Hecalus glaucescens* and *Mendrausus pauxillus*. At the forest side the outrush predominated in the populations of *Falcotoya minuscula, Paluda vitripennis, Austroagallia sinuata* and *Mendrausus pauxillus*.

In the autumn months the trends were not so clear. Only *Eupelix cuspidata* moved towards the pasture, while inrush of *Zyginidia pullula, Agallia laevis* and *Recilia schmidtgeni* could be measured. At the forest side two species moved from the forest (*Turrutus socialis* and *Recilia schmidtgeni*), the others moved in the

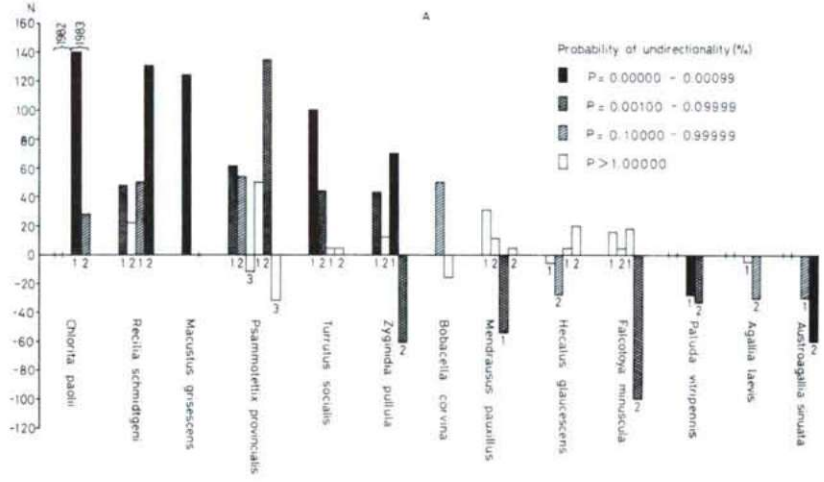

Fig. 6.A) Differences of numbers of „immigrant" and „emigrant" individuals of dominant *Auchenorrhyncha* species at forest side, from data summed up according to subpopulations (1,2,3). Graphs of the two experimental years are separated.

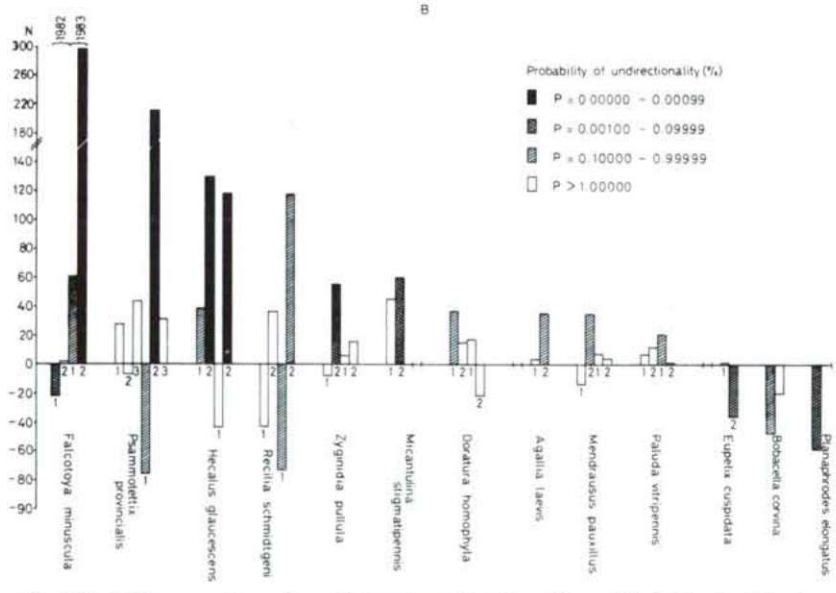

Fig. 6.B) Differences of numbers of „immigrant" and „emigrant" individuals of dominant *Auchenorrhyncha* species at pasture side, from data summed up according to subpopulations (1,2,3). Graphs of the two experimental years are separated.

direction of forest (*Zyginidia pullula, Paluda vitripennis, Agallia laevis, Austroagallia sinuata*).

The seasonal activity peaks of adults of the three most abundant *Acridoidea* populations (*Euchorthippus declivus, Chorthippus longicornis* and *Stenobothrus crassipes*) appeared equally in July (Fig. 7.A-C), but the maximal activity of *S. crassipes* may shift over August (see in 1983). It is evident, that these three populations are responsible for seasonal movement trends characteristic for whole *Acridoidea* fauna, which is shown at Fig. 4. The single directionalities are nearly the same. Deviation was found in the case of *S. crassipes* at forest boundary, where the

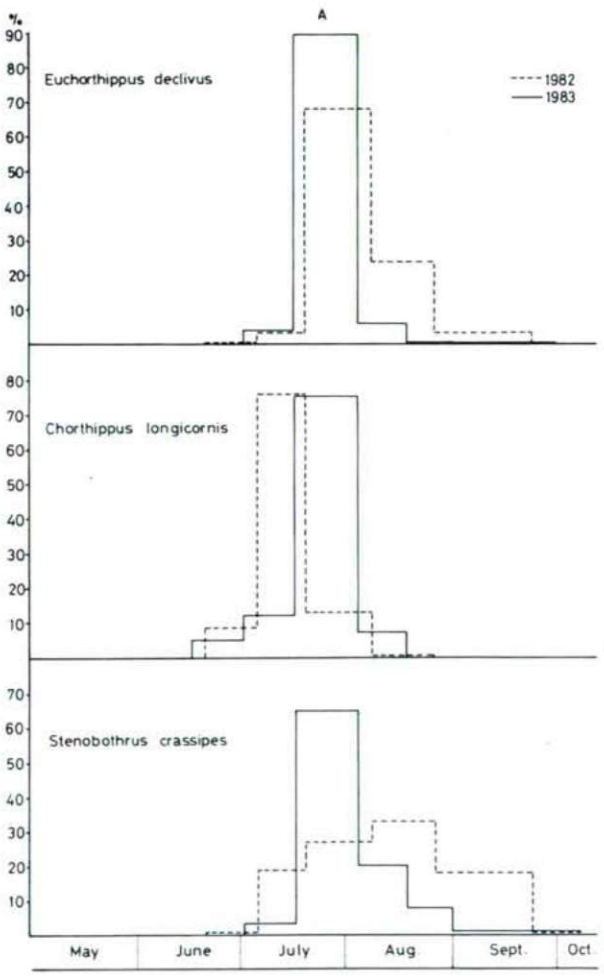

Fig. 7.A) Seasonal distribution of imagos of grasshopper populations.

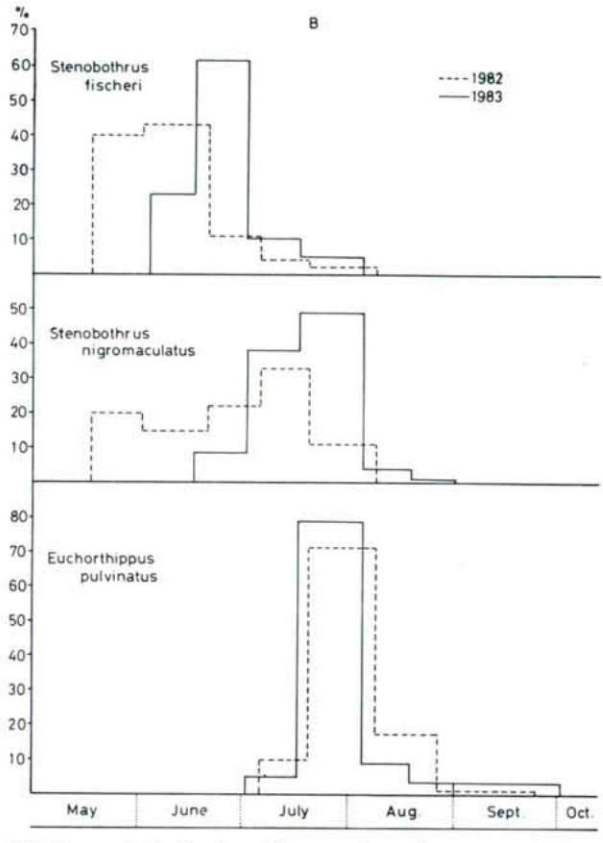

Fig. 7.B) Seasonal distribution of imagos of grasshopper populations.

significance of directionality decreased, and in the case of *C. longicornis* only the direction could be detected in 1982 (probably because of low individual number). In totality significant and intense inrush from the pasture and less intense, but significant outrush to the forest happened additively in both years in case of these three populations. This scheme of directionality of pasture ⇨ forest in reflection of individual turnover passing through the boundary zones is shown by Fig. 8.A-B. These figures demonstrate well the very diverse proportions of the populations.

The distribution of individuals of *Stenobothrus fischeri*, *S. nigromaculatus* and *Euchorthippus pulvinatus* populations, density of which was less then that of species mentioned above, was more balanced at the two sides of traps. Between the sides of traps such effects stood out that were opposite and suppressed directionality. Movement of these populations is qualified undirectional on the basis of the analysis. Seasonal segregation may have a role in this in addition to the above mentioned.

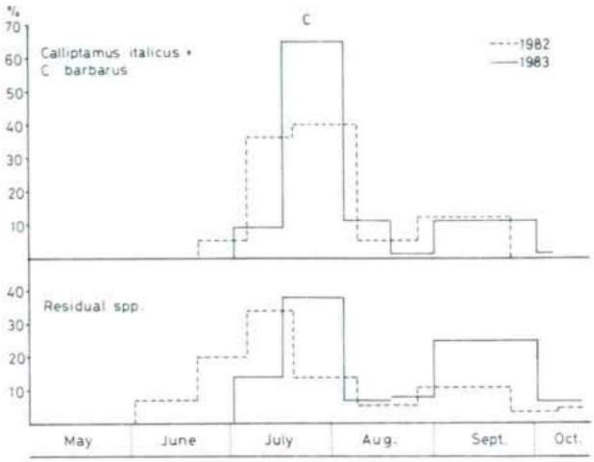

Fig. 7.C) Seasonal distribution of imagos of grasshopper populations.

We analysed the joint populations of *Calliptamus italicus* and *C. barbarus* because of the low number of individuals (in the examination period their abundance really decreased, and we can suppose that this collecting method is less adequate for them). Likewise, because of the low individual number, we joined the residual populations (populations regularly with low density) as a „residual" group, and evaluated their common movement. As it could be expected, we could not detect directionality in case of the two later groups, though the rate of their individual turnover directing to the experimental grassland patch exceeded that of emigration in both boundary zones, in both years, both in summer and in autumn aspect.

Discussion

On the basis of studies dealing with habitats of similar type, we could suppose that the herbivore communities living on our experimental field have larger species set than those living on the pasture. This hypothesis was based on the properties of the habitat, such as larger diversity of microhabitats, larger phytomass (ANDRZEJEWSKA and GYLLENBERG, 1980; NAGEL, 1979), more comfortable microclimate (MÜLLER, 1980; MYERS, 1980), differences in the architecture of vegetation (LAWTON and SCHRÖDER, 1978; LAWTON, 1983; STINSON and BROWN, 1983), and presence of more, potential host plant species (MURDOCH et al., 1972; SOUTHWOOD et al., 1979).

Above hypothesis is authentic in the case of *Auchenorrhyncha* communities for the fauna of pasture parts farther from the boundary zone (GYÖRFFY unpublished data), but regarding the boundary zone the differences are not significant. In this zone the structure of joining vegetations is much more similar, than at the forest side

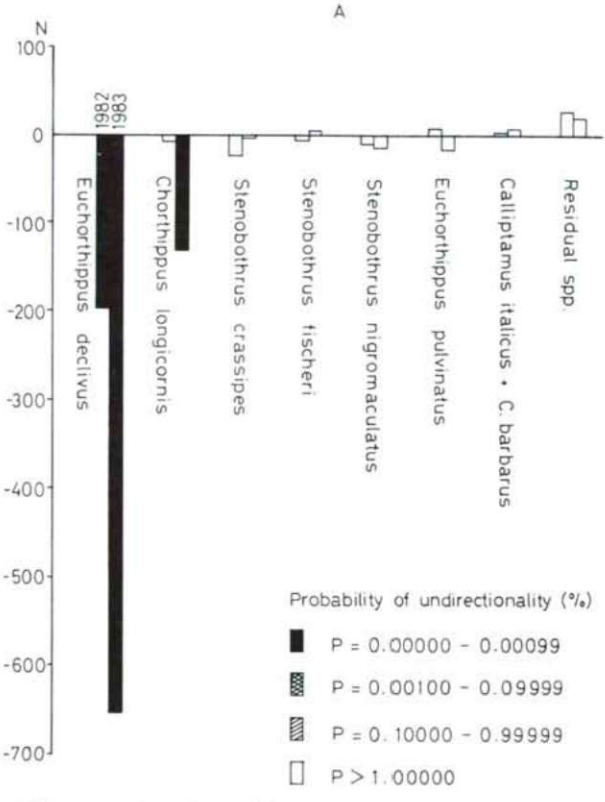

Fig. 8.A) Differences of numbers of „immigrant" and „emigrant" individuals of grasshopper populations at forest side, from summed data.

where the differences in species number are more considerable (cf. JAGOMÄGI et al., 1988). Shading effect of the forest also can be regarded at later site. Because of this the differences in the species number of *Auchenorrhyncha* communities, mobility of which is relatively lower, are important, while the species number of *Acridoidea* communities of larger mobility is the same everywhere.

Previous data also predicted that the probability of immigration is larger from the pasture to the experimental area. Active and directed movements can be increased by attractive effect of larger amount of phytomass (ANDRZEJEWSKA, 1971), by effect of quality of habitat to movement activity CLARIDGE et al., 1977; DENNO, 1985; THOMAS and SINGER, 1987), by small size of sampling area (GARBARCZYK, 1987), as well as by property of more varied architecture decreasing the wind effect (LEWIS, 1969).

This inrush expected from direction of pasture was experienced in both communities. In the case of *Auchenorrhyncha* the attractive effect of the sampling area increased mainly in the summer months in accordance with microclimate.

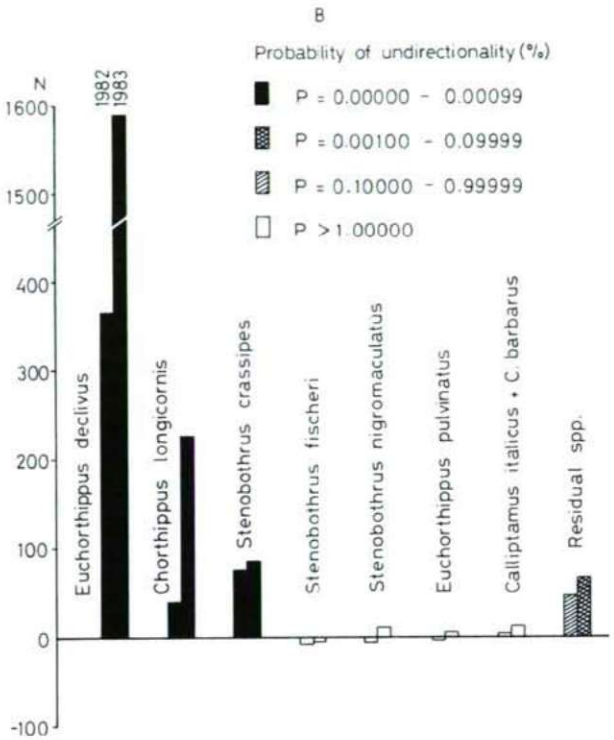

Fig. 8.B) Differences of numbers of „immigrant" and „emigrant" individuals of grasshopper populations at pasture side, from summed data.

Community of ungrazed area shared in species supply for the pasture in spring and autumn period, and ensured the intering of some populations arriving from the pasture in autumn, respectively.

The pasture gives a continuous supply for the sampling area considering the *Acridoidea* community.

On the basis of 17 examined *Auchenorrhyncha* populations we did not find such consistent trends appearing in both years, as was found at grasshoppers. Causes of this may be the less mobility and, connected with this, the coarse—grained behaviour (GALLÉ et al., 1985), the greater claim for host plants, the larger sensitivity to microclimate (and macroclimate), and in many case preferring the dormancy to migration.

As a result of their coarse—grained behaviour certain populations were of different abundance in the neighbourhood of some traps (e. g. *Gravesteiniella boldi*, *Agallia sinuata*, *Eupelix cuspidata*, *Hecalus glaucescens*, *Macustus grisescens*, *Falcotoya minuscula*) in spite of the fact, that we tried to place the traps in similar habitats. Because of this the differences in probability of directionality calculated

for each trap were often large, sometimes with opposite trends, that vitiated the value of significance.

More intense and significant directed movements are characteristic for populations of large density in grasshopper communities. KAUFMANN (1965) reported a density dependent, tough larval mass migration, and pointed out ordinal relation between density and speed of migration. No doubt that in our case the density effect has another sense, and it means not mass migration but increased frequency of directed movement pattern deriving from the large individual number. We can suppose from the significant undirectionality of relatively low density populations, that ecological conditions of the area are favourable for them, there is no stress to cause movements, since they segregate seasonally, their density is low, so there is no competition. Movement of „residual species" group supports this hypothesis, since it reflects to attractive and retaining effect of the area from both directions.

It is easy to understand, that in this experiment movement types of grasshoppers are in correlation with fine—grained projection of environmental heteromorphy (GALLÉ et al., 1985; SZŐNYI and KINCSEK, 1986), but we can not neglect that the populations are different in the preference of vegetational patches. ANDERSON (1964) studied the patch selection of grasshoppers, and determined its causes in correlation between taxonomic composition of vegetation and feeding type of grasshoppers. His final conclusion was that distribution of grasshoppers is nonrandom. Many case studies (e. g. FARROW, 1982; JOERN, 1983) support, that movement pattern of several grasshopper communities is very different, consequently large differences have to be supposed in their microhabitat selection.

Aknowledgement

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DIE AUSBILDUNG SEKUNDÄRER GESCHLECHTSMERKMALE BEI UNGARISCHEN MÄDCHEN

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Zusammenfassung

Beim Menschen ist die Entwicklung der sekundären Geschlechtsmerkmale eines der sichersten Anzeichen für den Beginn der Pubertät. In den Jahren 1981—1984 untersuchte der Verfasser in Ungarn den Entwicklungsgrad der sekundären Geschlechtsmerkmale bei 16000 Mädchen und gibt gleichzeitig einen Überlick über deren Ausprägung bei 18248 ungarischen Mädchen im Zeitraum zwischen 1968 und 1984.

Anhand des zur Verfügung stehenden umfassenden Datenmaterials lässt sich konstatieren, dass der 50%-Grad der Erwaschsenenentwicklung für die Brüste bei 11.60—12.75; für die Schambehaarung bei 12.10—13.00 und für die Axillarbehaarung bei 12.40—13.40 Jahren liegt (Methodik nach TANNER, 1962 und GRIMM, 1966). Der Menarchemedian für die Jahrgänge 1981—1984 liegt in Ungarn bei 12.79 Jahren.

Schlüsselwörter: Sekundäre Geschlechtsmerkmale, ungarische Mädchen, Axillarbehaarung, Schambehaarung, Brustentwicklung.

Einführung

Beim Menschen ist die Entwicklung der sekundären Geschlechtsmerkmale eines der sichersten Anzeichen für den Beginn der Pubertät. Dieser Prozess wird durch das Ansteigen der Produktion von Sexualhormonen sowie die Verringerung des im Corpus pineale produzierten und im Blutserum zirkulierenden Melatonins stimuliert (Abb. 1).

Um über das Reifestadium einer Kinderpopulation ein zuverlässiges Bild zu bekommen, bedient man sich verschiedener Möglichkeiten:

1. Bestimmung des Melatoninspiegels im Blutserum mittels der Radio-Assey-Methode
2. Bestimmung des Titers der Sexualhormone
3. Bei Mädchen die Bestimmung des Menarchezeitpunktes und bei Jungen das Auftreten der ersten Pollution mit prospektiven und restrospektiven Verfahren oder mit der Status-quo-Methode
4. Untersuchung der verschiedenen Entwicklungsstadien der sekundären Geschlechtsmerkmale
5. Bestimmung der Stufen der körperlichen Entwicklung (morphologisches Alter).

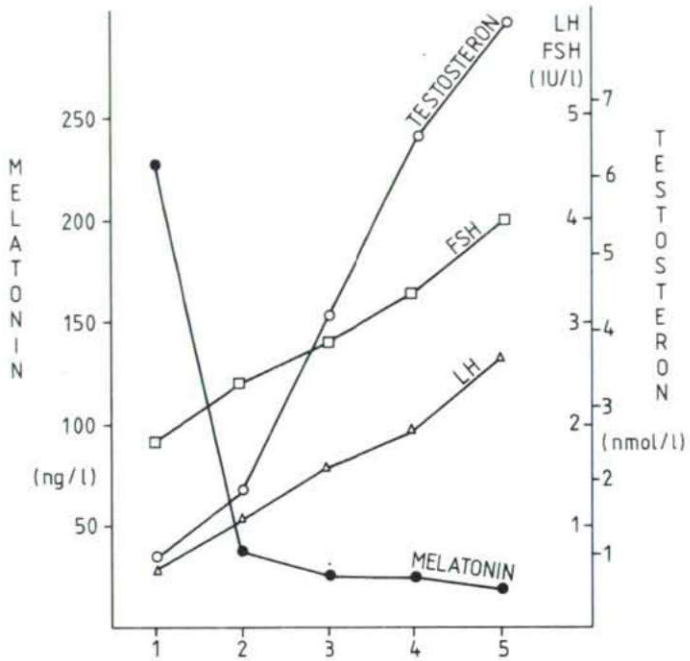

Abb. 1. Veränderungen des Gehalts an Melatonin und Sexualhormonen entsprechend der Entwicklungsstufe der männlichen Genitalien (nach SILMAN et al. 1979).

Verglichen zu den anderen sind die beiden erstgenannten Verfahren die genaueren, ihre Anwendung ist jedoch zeit- und kostenaufwendiger. Die drei anderen Methoden lassen nur eine indirekte Bestimmung zu, man kann sie aber auf eine grosse Stichprobenanzahl ausdehnen und mit verhältnissmässig geringen finanziellen Mitteln durchführen.

Material und Methode

Die in den Jahren 1981—1984 durchgeführten Untersuchungen zum Menarchealter der Mädchen erfolgten mit Hilfe der Status-quo-Methode auf der Grundlage anonymer Fragebögen. Von 32000 Mädchen erhielten wir 34 Basiswerte und ausserdem von 22000 Jungen die Körpermasse (Körpergewicht, Körpergrösse, normaler Brustumfang). Ziel dieser Untersuchung war das Auffinden eines Zusammenhanges zwischen dem Menarchezeitpunkt und sozio-ökologischen Faktoren.

Ausser dem Menarche-Median bestimmten wir den Entwicklungsgrad der sekundären Geschlechtsmerkmale. Dabei bezogen wir uns auf die Schriften von TANNER (TANNER, 1962). Bei dieser Untersuchung bestimmten wir die Entwicklung der Brüste sowie der Axillar- und Schambehaarung mit Hilfe von Fotografien und den zugehörigen Beschreibungen und fertigten ein Entwicklungsschema bzw. -skala an. Bei dieser Form der Datenerfassung hat man die Möglichkeit einzelne unklare Fälle erneut zu kontrollieren und sachlich zu klären.

Den Entwicklungsgrad der sekundären Geschlechtsmerkmale bestimmten wir mittels einer 12-Punkte-Skala (GRIMM, 1966), wobei anhand des dezimalen Lebensalters der Grad der

Erwachsenenentwicklung auf dem 50%-er Niveau dem Lebensalter zugeordnet wird. Um den Umfang methodischer Fehler zu verringern, wurden die sekundären Geschlechtsmerkmale eines jeden Mädchens von ein und derselben Person (Assistentin) beurteilt. Bei den Messungen der somatometrischen Daten verfuhren wir gleichermassen. Die sekundären Geschlechtsmerkmale wurden so von 16000 Mädchen begutachtet. An den Mittelschulen hatten wir dazu keine Möglichkeit.

Die Analyse der Daten erfolgte am László-Kalmár-Laboratorium für Kybernetik der Universität Szeged mittels Osiris-Programms auf einem R-55-Rechner.

Diskussion

Über die Entwicklung der sekundären Geschlechtsmerkmale ungarischer Mädchen liegen nur wenige Angaben vor.

Erwähnen möchten wir hier in erster Linie eine Publikation von JÓNÁS und Mitarbeiter (1966), die Beobachtungen an 500 Mädchen aus ostungarischen Städten und Dörfern enthalt. Ebenfalls in Südungarn machten wir eine Untersuchung mit nicht zu grossem Umfang in den Jahren 1966—1967 in Szeged (FARKAS, 1969).

Eine weitere Untersuchung erfolgte durch BODZSÁR an 1118 Mädchen in Dörfern des nördlich des Balaton gelegenen Bakony-Gebirges in den Jahren 1977—1978 (BODZSÁR, 1983). Angaben aus allen Landesteilen, aber mit mehr als der Hälfte aus Südungarn, das heisst mehr als 16000 Mädchen, wurden in einer Untersuchung 1981—1984 mitgeteilt (FARKAS, 1986). Ein Teil dieser Untersuchungen kommt aus der südwestlich der Donau gelegenen Stadt Nagyatád, wo 857 Mädchen 1982 untersucht worden waren (VÁRHEGYI, 1985).

Es sei darauf hingewiesen, dass BORSOS und Mitarbeiter in erster Linie unter kindergynäkologischen Gesichtspunkten eine 5-stufige Skala ausgearbeitet haben, in deren Bewertung die Ausbildung der Brüste, der Axillar- und Schambehaarung, des Uterus sowie die der zytologischen Abstriche eingeht (BORSOS und Mitarbeiter, 1982). Unter vergleichsweise ähnlichen kindergynäkologischen Aspekten erfolgte durch ÖRLEY auch eine in drei Stufen angelegte Untersuchung an Budapester Mädchen (ÖRLEY, 1975). Doch in den beiden zuletzt erwähnten Arbeiten finden sich keine konkreten Hinweise auf die Entwicklung der sekundären Geschlechtsmerkmale.

Diese Aufstellung gibt einen Überblick über die Entwicklung der sekundären Geschlechtsmerkmale bei 18248 ungarischen Mädchen im Zeitraum zwischen 1968 und 1984 (Tabelle 1). Diese Beobachtungen haben aber eine unterschiedliche Anzahl an Elementen und entstammen geografisch unterschiedlichen Gegenden.

Ausserordentlich gering ist die Zahl der Publikationen, die sich mit der Entwicklung der sekundären Geschlechtsmerkmale oder Reifung bei ungarischen Jungen befassen (DEZSŐ, 1965; JÓNÁS und Mitarbeiter, 1968; FARKAS, 1969). Das scheint seine Ursache in der Schwierigkeit der genauen Erfassung dieser Veränderungen zu haben.

Anhand der uns zur Verfügung stehenden Angaben können keine weitreichenden Schlussfolgerungen gezogen werden. Doch zumindest lässt sich

Tab. 1. Der 50%-Grad der Erwachsenenentwicklung für Brüste, Axillar- und Schambehaarung bei ungarischen Mädchen (zusammengestellt nach mehreren Autoren)

Verfasser	Jahr	Ort	n	50% Entwicklung (Lebensalter)		
				Mammae	Pubes	Axillae
FARKAS	1966/67	Szeged	368	12.50	12.25	13.40
JÓNÁS et al.	1968	Debrecen	226	11.60	12.10	13.15
JÓNÁS et al.	1968	Umgebung Debrecen	96	11.85	12.90	13.40
BODZSÁR	1977/78	Bakony	1118	12.75	13.01	13.21
VÁRHEGYI	1982	Nagyatád	857	11.80	12.20	12.40
FARKAS	1981/84	Ungarn	16431—16440	12.44	12.60	12.60

sagen, dass der 50%-Grad der Erwachsenenentwicklung für die Brüste bei 11.60—12.75; für die Schambehaarung bei 12.10—13.01 und für die Axillarbehaarung bei 12.40—13.40 Jahre liegt. Solch eine Gesetzmässigkeit, dass zum Beispiel bei den Stadtmädchen die Entwicklung früher einsetzt als bei Mädchen vom Lande, liess sich nicht nachweisen. Das scheint aber an der Natur der Erhebung zu liegen, denn es wurden sehr unterschiedliche Grundgesamtheiten verwendet was die Fehlerrate vergrössert, es bestand eine sehr grosse Streuung in den Zeitpunkten der Datenerfassung, und die Angaben entstammten sehr unterschiedlichen geografischen Gegenden. Dennoch erhielten wir ein zuverlässiges Bild über die Entwicklung der sekundären Geschlechtsmerkmale bei ungarischen Kindern. Notwendig ware allerdings eine sorgfältig geplante, ausreichend grosse Untersuchung unter Berücksichtigung aller Gebiete des Ungarns und deren sozio-ökologischen Besonderheiten. Eine Schätzung des Pubertätsbeginns, sowie die daraus erwachsenden Aufgaben für die Erziehung sind ohne exakte Angaben nur schwer durchführbar.

Doch für die Realisierung solch einer Zielstellung, von ungarischen Kindern die notwendigen Angaben zu erhalten, haben wir aufgrund der für solche Untersuchungen fehlenden materiellen Mittel nur wenig Hoffnung; und dennoch waren solche Forschungen notwendig, um Eltern, Ärtzten und Lehrern objektive Beurteilungskriterien an die Hand zu geben. In gewissem Umfang helfen uns die Erkenntnisse aus unseren Untersuchungen in den Jahren 1981—1984, wo wir eine Möglichkeit zur Bestimmung des Menarchezeitpunktes aufzeigten und auch eine Bewertung der Ausbildung der sekundären Geschlechtsmerkmale vornahmen.

Solch eine in der Zukunft notwendige Analyse könnte nicht nur neue Informationen über den Reifungsprozess bei ungarischen Kindern erbringen, sondern auch dem Vergleich mit Angaben aus dem Ausland dienen.

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BIOLOGICAL DISTANCE IN THE 5—11TH CENTURIES POPULATIONS USING NON-METRIC FREQUENCY DATA

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Abstract

A sample of 807 crania representing two 5—6th, ten 6—8th, one 9—10th, one 10th and two 10—11th century populations were scored for 42 non-metric cranial traits in order to generate biological distance between these groups, elucidate migration patterns, or show genetic differences among these populations. Standard biological distance statistics were used to show the divergence among these groups and numerical taxonometric computer programs were utilized to display the relevant associations within and among these populations. Population samples under study were checked for side, sex and age dimorphism and dependencies of the traits utilized. It was found that while many of the Avar populations grouped together very well, some of the 5—6th populations grouped more closely with the 10—11th centuries materials than they do with the 6—8th centuries (Avar period) material. Some of this may be dues to small sample sizes for some of the 10th century Hungarian Conquest material.

Key words: biological distance, non-metric traits, 5—11th centuries (Gepid, Avar, Hungarian Conquest, Arpadian Age)

Introduction

Our ability to analyse the skeletal remains of earlier human populations by the use of non-metric and numerical taxonometric statistics has, to a considerable degree, added to the existing anthropological method of morphological taxonomy and metric analysis. Indeed, the sensitivity of the non-metric analysis may be used in assigning an individual cranium to one of a number of ethnic groups (FINNEGAN and MCGUIRE, 1979; FINNEGAN and RUBISON, 1984), to help in the identification of basic demographic parameters used in establishing individual identity in modern forensic anthropology (FINNEGAN, 1977), or in delineating microevolutionary changes (JANTZ, 1970; ORTNER and CORRUCCINI, 1976). However, in the broader sense, non-metric analysis has been most often used in comparing various populations with respect to biological distance (see FINNEGAN and FAUST, 1974; FINNEGAN, 1978 for detailed references).

Some of the most interesting migration patterns have occurred in Central Europe during the first millennium A. D. Some of the migrations of this period have been suggested on the basis of skeletal morphological taxonomy and fewer by robust metric statistical techniques, but only six of the populations from the Carpathian Basin have been studied with respect to non-metric traits (FINNEGAN

and MARCSIK, 1979). The purpose of this paper is to report continued analysis of earlier Hungarian populations using non-metric traits and numerical taxonometric statistics.

Material and method

Crania of 411 males and 396 females, representing 16 samples, two Gepid (5—6th c.) samples, 10 Avar (6—8th c.) period and one 9—10th c., three Hungarian Conquest and Early Arpadian aged (10—11th c.) samples were used. All samples are stored in the Department of Anthropology, Attila József University, Szeged, Hungary. Specifies samples are presented by name, cite location, sample size and rough date in Table 1. These samples are further elaborated for physical anthropology by one or more of the following: BARTUCZ, 1936; KŐHEGYI and MARCSIK, 1971; LIPTÁK, 1983; LIPTÁK and MARCSIK, 1966; 1970; 1976; LIPTÁK and VÁMOS, 1969; LIPTÁK and VARGA, 1974; LOTTERHOF, 1971; MARCSIK, 1971; VÁMOS, 1973; WENGER, 1955.

Table 1. Sample names and references used in this analysis along with maximum sample sizes and rough age by century. Sample sizes approximate 2n for those traits with bilateral occurrence

Population Sample	Reference	Sample size (2n)	Rough age (cent.)
1. Kunszállás-Fülöpjakab	LIPTÁK—VARGA 1974	62	8th
2. Mélykút-Sáncdülő	MARCSIK 1971	68	6—7th
3. Debrecen-Árkus Homokbánya	(not elaborated)	44	8th
4. Madaras-Téglavető	LIPTÁK—MARCSIK 1976	98	8th
5. Szeged-Fehértó-A	LIPTÁK—VÁMOS 1969	200	8th
6. Szeged-Kundomb	LIPTÁK—MARCSIK 1966	162	8th
7. Szeged-Makkoserdő	VÁMOS 1973	160	8th
8. Sükösd-Ságod	KŐHEGYI—MARCSIK 1971	140	7—8th
9. Kiszombor-B(Gepid)	BARTUCZ 1936	88	5—6th
10. Szőreg-Téglagyár	(not elaborated)	72	5—6th
11. Szabadkígyós-Tangazdaság and others	LOTTERHOF 1971, LIPTÁK 1983	170	10—11th
12. Kiskörös-Város alatt	LIPTÁK 1983	178	8th
13. Szarvas-Kákapuszta	LIPTÁK—MARCSIK 1970	34	9—10th
14. Szentes-Kaján	WENGER 1955	82	7—8th
15. Szentes-Borbástanya	LIPTÁK 1983	18	10th
16. Kiszombor-B (Arpadian Age)	(not elaborated)	48	10—11th

Each cranium in each sample was scored by one of us (MF) for the 42 cranial non-metric traits following FINNEGAN and MARCSIK (1979), which can be used for reference. Seven of these traits are expressed only along the mid-sagittal plane and sample size is therefore dependent on the number of crania studied. The remaining 35 traits have the possibility of bilateral expression and the sample size for these traits is limited to the number of sides of crania or approximately twice the number of crania. Each population sample was checked for age dependency and side and sex dimorphism utilizing the theta derived (ΘX^2) statistic whose distribution is very nearly the same as the standard X^2, with one degree of freedom.

$$\Theta X^2 = \frac{(\Theta_{1i} - \Theta_{2i})^2}{1/n_{1i} + 1/n_{2i}}$$

The Grewal-Smith statistic (mean measure of divergence (MMD), see FINNEGAN and COOPRIDER, 1978), was used to generate all between sample distance measures based on the transformed frequencies of the observed non-metric traits:

$$MMD = \sum_{i=1}^{R} [(\Theta_{1i} - \Theta_{2i})^2 - (1/n_{1i} + 1/n_{2i})]/R$$

Where $\Theta_{1i} = \arcsin(1 - 2P_{1i})$,
P_{1i} = frequency of the ith trait in the sample 1,
N_{1i} = total sides or total crania in sample 1,
i = trait number under summation,
R = number of traits for a particular data set.

While the MMD distance are complete in themselves, further testing and geographic representation of the population samples are possible with numerical taxonometric statistics (SOKAL and SNEATH 1963; ROHLF, 1967; ROHLF et al, 1974). In this analysis the 16 dimensional matrix was subjected to a sequential agglomerative hierarchial cluster analysis (TAXON) using the unweighted pair-group method with arithmetic averages (UPGMA) using low values for similarity or least biological distance. A cophonetic value metrix was generated and compared to the original distance matrix for conguerence, which can be displayed as a bivariate scatter plot and can also be expressed as a correlation.

Results

While correlation analysis showed some age dependency, standard chi square analysis between younger and older crania showed the few significant differences to be less than chance expectation. Additionally, immature individuals had not been used in this analysis and the age range was generally between 20 and 60 years. Side to side differences were significant (ΘX^2) at or above .05 level in 3.72% of the male samples and 4.16% in female samples. While these differences are below chance expectation it should be noted that trait expression in a sample is rarely symmetrical and that these asymmetries can be used in ethnic identification of individual crania (FINNEGAN and MCGUIRE, 1979; FINNEGAN and RUBISON, 1984). In this analysis we have pooled left and right sides.

Sex differences were more pronounced generating 8.33% significant differences between males and females on each of the left and right sides comparisons. This exceeds chance expectation and some of these differences were significant at the .01 level or higher. However, these significant differences are more or less evenly distributed across the 42 traits with both sex comparisons by side, showing slightly more than 1 significant difference per trait. Similarly, most traits showed one or more significant sex differences across the 16 population samples treating left and right sides separately, suggesting some randomness to the distribution.

For analysis we have pooled our sides and sexes in generating our distance matrix for the following reasons: 1. the number of each sex is about equal in each population; 2. where significant sex differences occur we generally find them to be directional and similar in each population; 3. sex dimorphic traits have often proven to be the most important discriminators in showing population separation by principal component analysis (KELLOCK and PARSONS, 1979; FINNEGAN, 1972; BERRY, 1975; FINNEGAN, 1978; BERRY, 1979; FINNEGAN and MARCSIK, 1979).

The raw data for frequency and sample size are given in Tables 2 and 3. The

Table 2. Frequencies for each trait in each population sample used in this analysis with sides and sexes pooled.

CRANIAL NON-METRIC TRAITS:	HU 1	HU 2	HU 3	HU 4	HU 5	HU 6
1. HIGHEST NUCHAL LINE	.500	.391	.700	.511	.823	.642
2. CORONAL OSSICLES	.000	.000	.000	.011	.020	.037
3. OSSICLE AT BREGMA	.000	.000	.000	.021	.010	.000
4. SAGITTAL OSSICLES	.034	.000	.053	.021	.160	.037
5. OSSICLE AT LAMBDA	.033	.030	.200	.064	.204	.192
6. LAMBDOID OSSICLES	.204	.295	.406	.375	.469	.418
7. OS INCA	.000	.000	.000	.000	.000	.000
8. PARIETAL FOR.	.548	.603	.395	.559	.445	.542
9. PARIETAL NOTCH BONE	.100	.018	.000	.023	.116	.063
10. ASTERIONIC BONE	.000	.019	.000	.071	.060	.103
11. AUDITORY TORUS	.000	.000	.000	.000	.000	.000
12. MALAR TUBERCLE	.088	.000	.000	.000	.000	.000
13. OS JAPON	.019	.000	.000	.000	.010	.006
14. PTERION FORM	.056	.020	.000	.012	.020	.057
15. EPITERIC BONE	.056	.021	.200	.128	.278	.190
16. INFRA-ORBITAL FOR.	.021	.027	.000	.050	.060	.044
17. SUPRA-ORBITAL FOR.	.458	.263	.216	.280	.151	.167
18. FRONTAL FOR. PRESENT	.390	.179	.108	.228	.156	.222
19. METOPIC SUTURE	.097	.000	.050	.022	.102	.064
20. MANDIBULAR FOR.	.000	.019	.043	.058	.056	.039
21. MYLOHYOID GROOVE	.054	.035	.000	.011	.030	.033
22. MANDIBULAR TORUS	.288	.000	.000	.065	.056	.058
23. MENTAL FORAMEN	.119	.051	.065	.056	.081	.045
24. PALATINE TORUS	.148	.045	.071	.119	.162	.300
25. ACC. LES PALATE FOR.	.419	.433	.269	.228	.236	.483
26. FOR. OF VESALIUS	.325	.200	.182	.164	.218	.161
27. FOR. OVALE	.164	.067	.208	.059	.046	.053
28. FOR. SPINOSUM	.179	.227	.360	.165	.093	.171
29. FOR. OF HUSCHKE	.230	.220	.200	.250	.060	.043
30. CONDYLAR FACET	.000	.044	.000	.000	.026	.042
31. POST. CONDY. FOR.	.400	.490	.759	.711	.618	.599
32. PRECONDY. TUBERCLE	.040	.036	.000	.068	.080	.110
33. ANTERIOR CONDY. FOR.	.184	.115	.233	.115	.216	.167
34. MASTOID FOR.	.839	.725	.765	.837	.749	.850
35. MASTOID FOR. EXSUT.	.304	.196	.382	.244	.256	.183
36. PARAMASTOID PROCESS	.917	.829	.999	.919	.881	.852
37. DIGASTRIC GROOVE	.310	.264	.242	.267	.311	.281
38. STYLOMASTOID FOR.	.016	.000	.000	.000	.000	.000
39. ZYGO-MAX. TUBEROS.	.582	.442	.423	.506	.707	.732
40. ZYGO-FACIAL FOR.	.113	.354	.100	.198	.242	.217
41. ANT. ETH. FOR. EX.	.462	.619	.889	.370	.185	.200
42. POST. ETHMOID FOR.	.053	.263	.000	.160	.199	.083

HU 7	HU 8	HU 9	HU 10	HU 11	HU 12	HU 13	HU 14	HU 15	HU 16
.713	.692	.892	.686	.748	.551	.571	.688	.813	.933
.006	.000	.023	.031	.028	.028	.030	.050	.000	.042
.000	.015	.000	.029	.000	.000	.000	.000	.000	.000
.123	.046	.025	.000	.055	.024	.000	.083	.000	.091
.351	.156	.098	.194	.247	.181	.143	.182	.375	.174
.518	.425	.300	.554	.552	.420	.500	.462	.438	.267
.000	.000	.000	.000	.000	.000	.000	.000	.000	.042
.462	.485	.536	.493	.451	.500	.500	.679	.625	.646
.130	.111	.153	.048	.087	.070	.133	.095	.125	.130
.187	.081	.024	.111	.136	.053	.148	.154	.188	.149
.000	.000	.000	.000	.000	.017	.067	.012	.000	.104
.032	.020	.100	.071	.034	.086	.100	.056	.188	.128
.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
.058	.017	.012	.000	.000	.006	.030	.012	.000	.000
.134	.168	.247	.152	.128	.161	.161	.206	.188	.256
.018	.037	.085	.000	.088	.023	.031	.026	.118	.000
.127	.158	.214	.085	.138	.226	.294	.222	.333	.104
.199	.114	.167	.155	.242	.109	.176	.232	.333	.152
.063	.086	.093	.056	.048	.067	.059	.146	.000	.083
.069	.052	.141	.082	.085	.047	.071	.086	.067	.146
.061	.061	.095	.021	.030	.094	.037	.089	.000	.104
.058	.054	.000	.000	.167	.064	.000	.067	.438	.083
.059	.046	.045	.019	.091	.045	.100	.016	.313	.042
.029	.051	.049	.143	.066	.140	.250	.243	.778	.522
.271	.151	.200	.273	.206	.174	.172	.194	.188	.273
.115	.196	.333	.171	.271	.064	.000	.116	.214	.152
.088	.067	.081	.116	.028	.035	.034	.068	.063	.111
.115	.167	.137	.220	.096	.115	.107	.091	.000	.156
.131	.212	.081	.138	.156	.088	.033	.099	.000	.042
.025	.000	.000	.048	.000	.072	.000	.000	.000	.000
.598	.602	.658	.581	.644	.303	.286	.504	.688	.574
.044	.057	.000	.045	.000	.080	.125	.000	.000	.043
.183	.178	.253	.200	.163	.166	.097	.190	.125	.311
.897	.866	.901	.942	.905	.948	.000	.941	.938	.809
.375	.361	.444	.269	.250	.263	.464	.279	.125	.191
.912	.824	.781	.850	.765	.970	.966	.922	.875	.911
.224	.222	.253	.200	.207	.232	.276	.192	.125	.283
.013	.000	.000	.000	.000	.000	.000	.025	.000	.000
.350	.410	.284	.458	.370	.560	.412	.570	.611	.596
.192	.221	.165	.263	.142	.292	.030	.221	.176	.064
.388	.244	.132	.444	.406	.132	.167	.146	.286	.205
.512	.341	.185	.118	.185	.162	.120	.208	.000	.163

Table 3. Sample sizes for each trait in each population sample. Bilateral traits have the possibility of 2N, while midline traits have a maximum possibility of N, or the number of crania in the sample.

CRANIAL NON-METRIC TRAITS:	HU 1	HU 2	HU 3	HU 4	HU 5	HU 6
1. HIGHEST NUCHAL LINE	60.	64.	40.	88.	192.	151.
2. CORONAL OSSICLES	56.	59.	35.	94.	200.	160.
3. OSSICLE AT BREGMA	28.	29.	18.	47.	99.	81.
4. SAGITTAL OSSICLES	29.	32.	19.	47.	100.	81.
5. OSSICLE AT LAMBCA	30.	33.	20.	47.	98.	78.
6. LAMBDOIC OSSICLES	54.	61.	32.	88.	196.	153.
7. OS INCA	31.	33.	20.	46.	100.	78.
8. PARIETAL FORAMEN	62.	63.	38.	93.	200.	155.
9. PARIETAL NOTCH BONE	60.	56.	26.	86.	199.	159.
10. ASTERIONIC BONE	58.	53.	23.	84.	200.	155.
11. AUDITORY TORUS	61.	54.	32.	92.	200.	161.
12. MALAR TUBERCLE	57.	43.	34.	73.	200.	160.
13. OS JAPON	53.	42.	29.	81.	196.	157.
14. PTERION FORM	54.	49.	21.	86.	199.	158.
15. EPITERIC BONE	54.	47.	20.	86.	198.	158.
16. INFRA-ORBITAL FORAMEN	47.	37.	24.	60.	199.	159.
17. SUPRA-ORBITAL FORAMEN	59.	57.	37.	93.	199.	162.
18. FRONTAL FORAMEN	59.	56.	37.	92.	199.	162.
19. METOPIC SUTURE	31.	30.	20.	46.	98.	78.
20. MANDISULAR FORAMEN	56.	54.	21.	86.	197.	152.
21. MYLOHYOID GROOVE	56.	57.	20.	88.	198.	153.
22. MANDIBULAR TORUS	59.	59.	35.	92.	198.	156.
23. MENTAL FORAMEN	59.	59.	31.	90.	198.	155.
24. PALATINE TORUS	27.	22.	14.	42.	99.	80.
25. ACC. LES. PALATINE FOR.	43.	30.	26.	57.	191.	149.
26. FOR. OF VESALIUS	40.	25.	22.	67.	193.	143.
27. FORAMEN OVALE	55.	45.	24.	85.	197.	151.
28. FORAMEN SPINOSUM	56.	44.	25.	85.	193.	152.
29. FORAMEN OF HUSCHKE	61.	50.	30.	92.	199.	161.
30. CONDYLAR FACET	48.	45.	28.	78.	191.	142.
31. POST. CONDY. FOR.	45.	49.	29.	76.	191.	142.
32. PRECONDY. TUBERCLE	25.	28.	17.	44.	100.	73.
33. ANTERIOR CONDY. FOR.	49.	52.	30.	87.	199.	144.
34. MASTOID FORAMEN	56.	51.	34.	86.	195.	153.
35. MASTOID F. EXSUTURAL	56.	51.	34.	86.	195.	153.
36. PARAMASTOID PROCESS	48.	35.	15.	62.	193.	135.
37. DIGASTRIC GROOVE	58.	53.	33.	86.	196.	153.
38. STYLOMASTOID FORAMEN	61.	53.	27.	92.	198.	161.
39. ZYGO-MAX. TUBERCSITY	55.	43.	26.	77.	198.	157.
40. ZYGO-FACIAL FORAMEN	53.	48.	30.	86.	198.	157.
41. ANT. ETH. F. EXSUTURAL	26.	21.	9.	46.	157.	130.
42. POST. ETHMOID FORAMEN	38.	19.	10.	50.	171.	133.

HU 7	HU 8	HU 9	HU 10	HU 11	HU 12	HU 13	HU 14	HU 15	HU 16
136.	130.	74.	70.	143.	156.	28.	64.	16.	45.
156.	126.	86.	64.	141.	178.	33.	80.	18.	48.
78.	65.	42.	34.	73.	86.	17.	38.	9.	23.
73.	65.	40.	34.	73.	84.	15.	36.	7.	22.
74.	64.	41.	36.	73.	83.	14.	33.	8.	23.
139.	127.	80.	65.	134.	169.	24.	65.	16.	45.
76.	68.	43.	35.	81.	88.	14.	37.	8.	24.
156.	136.	84.	71.	153.	176.	28.	78.	16.	48.
146.	117.	85.	63.	138.	172.	30.	74.	16.	46.
134.	111.	84.	63.	132.	169.	27.	65.	16.	47.
151.	120.	87.	62.	156.	173.	30.	81.	18.	48.
124.	100.	80.	56.	117.	151.	30.	71.	16.	47.
125.	114.	80.	56.	118.	168.	33.	77.	17.	47.
139.	119.	86.	56.	141.	175.	33.	81.	18.	46.
134.	113.	77.	46.	117.	174.	31.	68.	16.	43.
114.	109.	71.	41.	102.	171.	32.	76.	17.	48.
157.	133.	84.	71.	152.	177.	34.	81.	18.	48.
156.	132.	84.	71.	153.	175.	34.	82.	18.	46.
80.	70.	43.	36.	83.	89.	17.	41.	9.	24.
130.	115.	85.	49.	129.	106.	28.	58.	15.	48.
132.	115.	84.	48.	132.	106.	27.	56.	15.	48.
137.	130.	88.	53.	144.	109.	28.	60.	16.	48.
136.	130.	88.	52.	143.	111.	30.	63.	16.	48.
69.	59.	41.	28.	61.	86.	16.	37.	9.	23.
96.	86.	60.	33.	68.	161.	29.	67.	16.	44.
96.	97.	72.	41.	85.	171.	28.	69.	14.	46.
125.	104.	74.	43.	106.	172.	29.	74.	16.	45.
131.	108.	73.	41.	115.	174.	28.	77.	16.	45.
153.	118.	86.	58.	154.	170.	30.	81.	18.	48.
121.	99.	75.	42.	99.	167.	29.	54.	15.	45.
117.	98.	73.	43.	104.	165.	28.	55.	16.	47.
68.	53.	39.	22.	50.	88.	16.	32.	8.	23.
126.	101.	75.	45.	104.	175.	31.	63.	16.	48.
136.	97.	81.	52.	116.	172.	28.	68.	16.	47.
136.	97.	81.	52.	116.	171.	28.	68.	16.	47.
102.	85.	64.	40.	85.	169.	29.	51.	16.	45.
147.	117.	83.	55.	150.	164.	29.	73.	16.	46.
152.	119.	87.	61.	157.	174.	30.	81.	18.	48.
123.	117.	81.	59.	119.	175.	34.	79.	18.	47.
125.	113.	79.	57.	120.	171.	33.	77.	17.	47.
85.	86.	53.	18.	64.	159.	30.	48.	14.	44.
84.	91.	54.	17.	65.	160.	25.	53.	15.	43.

mean measure of divergence among all populations, males and females, left and right sides all pooled, is given in Table 4. All between population differences are significant at the .05 level and most are significant are the .01 level. Figure 1 represents the 16 by 16 population clustered distance matrix as a phenogram, computed by the unweighted pair group method based on arithmetic averages. Low distance values were specified to indicate the corresponding distance similarities. When the cophonetic value matrix was plotted against the original distance matrix, little distortion was found in the bivariate plot of the two matrices and they produced a correlation of 0.777. While we belive this correlation is significant, SOKAL and DERISH (1988) (see also DERISH and SOKAL, 1988) suggests highly significant cophonetic correlations should be in the neighborhood of 0.85. Considering the size, spatial and temporal distribution of our population samples we feel the cophonetic correlations to be quite good.

Discussion

The distance phenograph (Figure 1) nicely divides into three major groups with four, more or less, single samples if we consider an identity level of 0.055. While this choice is somewhat arbitrary, it does fit the various time periods and allows some confidence in the phenogram and our overall analysis.

Group 1 is composed of Gepid samples, one middle and two late Avar period samples and the heterogeneous sample from the 10—11th century. Most of these samples fall within a 500 year time range and are distributed across southern Hungary.

Group 2 includes four samples, three representing the late Avar period and one from the Hungarian Conquest-Early Arpadian Age. Here the temporal range is about three centuries and the lowest biological distance is found between two late Avar period samples which are spatially separated by a few kilometers. The overall similarity in this group is somewhat greater than that found in group one, but it is composed of fewer samples with reduced temporal and spatial distributions.

Group 3 represents one late Avar and one 9—10th century samples from south central Hungary. We might have expected these population samples to have been part of group 2, expect for the fact, as noted by LIPTÁK (1983), that sample 12 shows a sex difference with respect to the proportion of Mongoloid morphological characters — females displaying more. As well, sample 13 shows a Europid-Mongoloid mix and may be one of the latest Avar period populations-possibly surviving into the 10th century (SZABÓ, 1966).

The remaining population samples are grouped above our arbitrary level of 0.055 and are not specific enough to be meaningful as a group. This is supported by the fact that sample 1 is a late Avar sample with a noticeable amount of Mongoloid morphological features, and is spatially distant from our other Avar period samples. Sample 2 is very early, possibly representing the „first wave" of Avar migration. As well, this sample represents two large families, rather than a random sample of a

Table 4. Measure of Divergence (biological distance) between population samples used in this study. All distance measures are significant ($p<.05$) and most are very significant ($p<.01$).

Population Sample	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
1. Kunszáll	.000															
2. Mélykút	.072	.000														
3. Árkus	.116	.085	.000													
4. Madaras	.051	.018	.066	.000												
5. Fehértó	.115	.117	.138	.045	.000											
6. Kundomb	.087	.082	.140	.034	.020	.000										
7. Makkoserdő	.131	.094	.142	.056	.053	.078	.000									
8. Sükösd	.088	.062	.116	.014	.030	.058	.014	.000								
9. Kiszombor	.125	.121	.143	.071	.062	.095	.068	.025	.000							
10. Szőreg	.111	.046	.060	.023	.053	.038	.040	.020	.049	.000						
11. Szabadka	.098	.094	.113	.033	.050	.068	.032	.019	.044	.033	.000					
12. Kiskörös	.099	.094	.165	.052	.055	.048	.063	.041	.081	.035	.074	.000				
13. Szarvas	.137	.145	.181	.076	.108	.080	.085	.072	.091	.052	.100	.019	.000			
14. Sz-Kaján	.095	.119	.151	.038	.035	.036	.039	.025	.039	.031	.031	.022	.039	.000		
15. Sz-Borbás	.150	.260	.246	.140	.137	.106	.203	.179	.180	.146	.095	.145	.137	.094	.000	
16. Kiszombor	.138	.188	.173	.100	.058	.062	.102	.081	.075	.067	.086	.077	.081	.026	.088	.000

larger population (FARKAS, LENGYEL and MARCSIK, 1971). Sample 3 represents a population geographically removed from southeastern Hungary. This sample was a priori chosen to serve as a control sample. Sample 15 represents a Hungarian Conquest single great family (LIPTÁK, 1983). As such, the variation in this sample may be reduced and, like sample 2, does not necessarily represent the larger population. This is also the smallest sample studied.

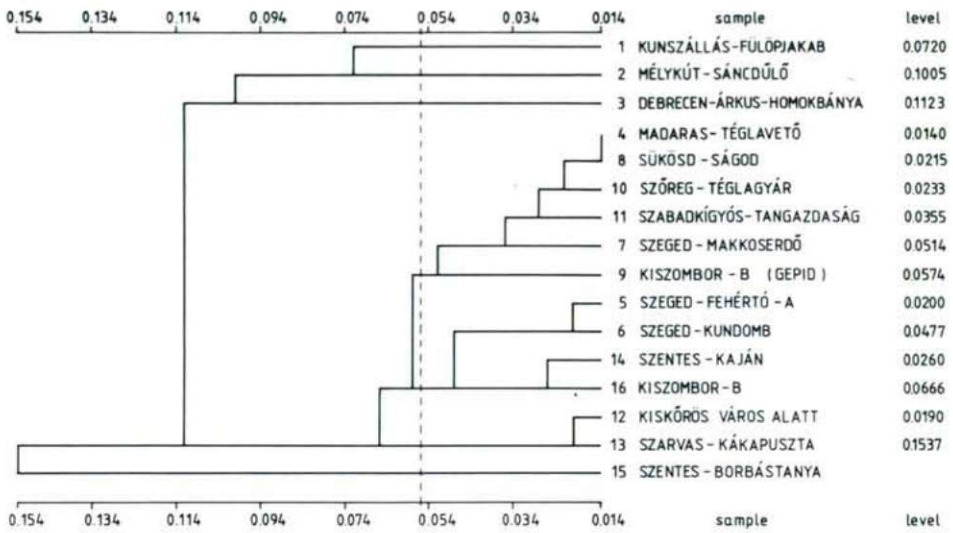

Fig. 1. A phenogram based on the clustered distance matrix (males and females; left and right sides pooled) using the unweighted pair-group method with arithmetic averages. Low values were specified to indicate corresponding distance similarities. Abscissa is scaled in relative population distances.

Admittedly, the cluster process in the numerical taxonometric system is somewhat artificial. For example, sample 8 generated a biological distance of 0.014 with both samples 4 and 7. The fact that the phenogram joins sample 8 with sample 4 is due to the fact that in the clustering process sample 4 is encountered and clustered before sample 7. Then, because of arithmetic averaging, all other values of samples 8 and 4 are averaged, including the value between samples 8 and 7. Nevertheless, sample 7 is clustered within the group containing samples 4 and 8. In addition, other transformations of the frequencies could have been used which may have altered the distance statistic, but here we used the transformation recommended by FINNEGAN and COOPRIDER (1978).

In this research we have shown the biological relationships among samples of earlier human populations, representing some of the Gepid tribes of the 5—6th centuries, the Avar period during the 6—8th centuries, and some Hungarian Conquest populations of the 10th and 11th centuries. While we can suggest general migration patterns in this broad region over time, the present analysis does not further identify or delimit time, direction or distance specifically. As our research

into population behavior in the Carpathian basin during the 5—11th centuries continues, and as the archaeology of these populations is explored in greater depth, we may be better able to identify and trace the migrations of earlier human populations in this area.

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UNTERSUCHUNGEN AN AUS AUSGRABUNGEN STAMMENDEN ZÄHNEN UND KIEFERN IN UNGARN (LITERATURÜBERSICHT)

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Zusammenfassung

Diese Untersuchungen werden vom Autor mit einer übersicht der Literatur der an aus Ausgrabungen in Ungarn stammenden Zahn- und Kieferfunden durchgeführten Forschungen zusammengefasst.

Das bibliographische Material wird gruppiert: normalen Variationen bzw. pathologischen Veränderungen der Kieferknochen, anthropologischen Beschreibungen der Zähne folgen zahnpathologische Beschreibungen. In die letztere Gruppe gehören Veröffentlichungen über die Zahnkaries, Zahnabnutzung sowie Folgeerkrankungen und Entwicklungsanomalien. Schliesslich befasst sich der Autor mit Veröffentlichungen zu an Kiefern und Zähnen durchgeführten Experimenten und pseudopathologischen Veränderungen sowie auch mit von ausländischen Autoren an ungarischem Material durchgeführten Untersuchungen.

Schlüsselworte: dental anthropology, -paleopathology, hungarian bibliographic review.

Einleitung

IGNÁC BARNA veröffentlichte 1871 das erste Zahnärztliche Lehrbuch in ungarischer Sprache. In dessen Einleitung zitiert er Herders romantische Beschreibung des Mundes, die lautet: „Kelch der Wahrheit, Becher der Liebe", und fährt fort: „bezüglich des guten Aussehens hängt die Form des Mundes von den Zähnen ab, durch sie wird er gestützt und erhält er beim Lachen seine bezaubernde Wirkung, ihre Erhaltung ist der Pfand der dauerhaften Schönheit, schöne Zähne und ein hässliches Gesicht scheinen ein Gegensatz zu sein, wohingegen ihr Verlust auch das schönste Gesicht abstossend macht, seiner Ursprünglichkeit entkleidet, ja es sogar entstellt, die Zahl der zu bedauernden Wesen, die der frühe Verlust ihrer Zähne schon im Frühling ihres Lebens in den eisigen Schoss der Verzweifelung stiess.!"

Schon unsere Vorfahren aus dem klassischen Altertum massen Zähnen und Gebiss Bedeutung bei. Denken wir nur an die Versuche zum Ersatz verlorener Zähne, an anfänglichen Zahnersatz, der aus etruskischen und ägyptischen Gräbern zum Vorschein kam. Auch im von 481 bis 741 unserer Zeitrechnung dauernden Merovingerzeit geschaffenen alemannischen Gesetzbuch (Germanenrechte, Lex Alamannorum) weisen einige Passagen auf die damalige Wichtigkeit der Zähne hin:

„&20. Wenn aber jemand einem andern mit einem Schlage die beiden ersten oberen Zähne (von den vorderen) ausschlägt, büsse er mit 6 Schillingen.

&22. Wenn (ein)er aber einen Zahn abschlägt, wozu die Alemannen Eckzahn sagen, büsse er mit 3 Schillingen."

Im folgenden wird das Strafmass zum Vergleich gezeigt:

„&30. Wenn (ein)er aber den Bart jemandes, der es nicht will, schert, büsse er mit 6 Schillingen.

&40. Wenn (der Arm) aber an der Schulter abgeschlagen wird, büsse er mit 80 Schillingen."

Die Zähne der Menschen dieser längst vergangenen Zeiten bedeuten auch uns, den späten Nachfahren, viel. Denn von allen Körperteilen ist es der Zahn, der unter den auch aus mehrere Millionen Jahre alten Schichten zum Vorschein kommenden Resten den postmortalen Wirkungen am besten wiedersteht, und deshalb das meiste nicht nur über die damaligen Lebewesen unmittelbar, sondern auch über deren Lebensumstände sagen kann.

Als erster schrieb wahrscheinlich DUBRUE DELASALLE 1772 eine Veröffentlichung über Beobachtungen in dieser Richtung, wozu wir einen Hinweis in CARABELLIS 1831 erschienenem Werk „Geschichtliche Übersicht der Zahnheilkunde" finden. Das Entsprechende in ungarischer Sprache zitiere ich ebenfalls aus BARNAS „Zahnmedizin" (1871): „DUBRUE DELASALLE stellte bei der Freilegung eines Friedhofes fest, dass von drei Schichten in der untersten bzw. der ältesten Schicht die Zähne der Skelette am intaktesten waren, die der obersten Schicht dagegen im schlechtesten Zustand. Daraus schoss er, dass dieser Unterschied der mit der Kultur verbundenen übertriebenen Gründlichkeit und der Schädlichkeit aller möglichen Reinigungsmittel zuzuordnen sei."

Über an umfangreicherem aus Ausgrabungen stammenden Fundmaterial mit wissenschaftlicher Gründlichkeit durchgeführte Untersuchungen publizierte MUMMERY 1870. Danach treffen wir immer häufiger Veröffentlichungen zu diesem Thema.

In erster Linie wurden die Zahnkaries, aber auch andere pathologische Zahnveränderungen untersucht. Daneben wurde die Kraniometrie zum vielleicht wichtigsten Zweig der bereits ausgebildeten anthropologischen Wissenschaft. Das bedeutet auch die Beschäftigung mit den normalen Variationen der Maxilla und Mandibula.

Ungarische Bibliographie

Die Untersuchungen an Zähnen geschichtlicher und vorgeschichtlicher Menschen durchführenden Forscher sind uns landesweise aus BRABANT und SAHLYS Arbeit „La paleostomatologie en Belgique et en France" (1962) bekannt. Bereits die Bezeichnung — Paleostomatologie — wurde von den Autoren von HUSZÁR übernommen (zit. BRABANT und SAHLY (1962), welcher die an aus Ausgrabungen stammenden Zahn- und Kieferüberresten durchgeführten

Untersuchungen so bezeichnete. SCHRANZ (1962) spricht in seiner sich mit Zahnbetterkrankungen befassende Veröffentlichung von Paleoparodontopathologie. Nach TÓTH (1970) gibt es an den aus Ausgrabungen stammenden Funden keinen Mund bzw. Stoma, deshalb unterstützt er die Bezeichnung Paleodontologie oder die Paleopathologie der Zähne und Kiefer.

Zurückkommend auf den Artikel von BRABANT und SAHLY (1962) erwähnen diese die Namen von LENHOSSÉK, NEMESKÉRI, SCHRANZ und HUSZÁR. Natürlich waren neben wohlbekannten Namen auch andere auf dem Gebiet der zahnärztlichen Paleopathologie und Paleoanthropologie tätig. Im folgenden überblicken wir die Veröffentlichungen ungarischer Autoren über Untersuchungen an solchem Material.

Das bibliographische Material wurde unterteilt. Zunächst werden die sich mit Normalvariationen bzw. mit pathologischen Veränderungen der Kiefer befassenden Veröffentlichungen und danach die Veröffentlichungen zur anthropologischen Beschreibung der Zähne besprochen. Bei den letzteren finden wir auch die Beschreibung der Zähne von geschichtlich bedeutenden Personen (Herrscher, berühmte Leute). Die Gruppen der pathologischen Veränderungen der Zähne sind Zahnkaries, Zahnabnutzung (Abrasion) und sich daraus ergebende sekundäre Knochenprozesse also parodontale Knochenveränderungen bzw. periapikale Prozesse. Die Entwicklungsanomalien der Zähne bilden eine eigene Gruppe. Schliesslich folgen die über an Kiefern und Zähnen durchgeführten Experimente, über pseudopathologische (postmortale) Veränderungen und über Untersuchungen an aus Ausgrabungen stammenden Zähnen im allgemeinen Auskunft gebende Studien und Buchkapitel. Es werden auch einige solche Veröffentlichungen erwähnt, die von ausländischen Autoren stammen, sich jedoch mit der Beschreibung ungarischer Funde beschäftigen. Die Autoren werden gemäss der chronologischen Erscheinung der Veröffentlichungen aufgezählt.

KIEFERMORPHOLOGIE

Mit der Korrelation und den Variationen der Neigung des Unterkiefers, sowie der Stellung der Längsachse des Gelenkkopfes beschäftigt sich TÖRÖK (1898, 1899). MIHÁLY LENHOSSÉK (1920) beschrieb die innere Oberfläche des Unterkieferastes. Ebenfalls dort führte SZOKOLÓCZY (1937, 1939, 1953) Messungen unter dem Gesichtspunkt der Leitungsanästhesie durch. Sehr bedeutend ist die Veröffentlichung von SIMON und KŐMŰVES (1937), in der sie die Masse und Stellungsvariationen des aufsteigenden Astes von 750 Unterkiefern studierten. APOR (1943) untersuchte die Unterkieferbreite, SOMOGYI (1953) die Typen des Kieferwinkels und die Besonderheiten des aufsteigenden Astes, KOLLÁR (1948) den Charakter der Mandibula der Vorzeit. NITSCHE und VÁLYI (1958) studierten die Konfigurationen (Messwerten, Symmetrie, pathologische Veränderungen) und Röntgenaufnahmen den 100 Capitulum mandibulae, die aus der Römerzeit und Árpádenzeit stammen. REGÖLY—MÉREI (1962) beschrieb an einigen Fällen die

senile Atrophie des Unterkiefers. Die Variationen der „Area perilingularis" untersuchten BALOGH und CSIBA (1966), DOBROVITS (1966) und später DOBROVITS und KEMÉNY (1971) untersuchten die Knochenoberfläche des retromolaren Gebietes. SZABÓ und DOBY (1972) studierten die Alterveränderungen des Winkels des Angulus mandibulae, BOTTYÁN (1973, 1974a, 1975) den zusammenhang zwischen Mandibula und Schädelkapazität, den geschlechtlichen Dimorphismus und gleichfalls die Veränderungen während des Lebens. KŐHEGYI und MARCSIK (1976) untersuchten am Material des Sükösder Awarenfriedhofes den Torus palatinus und Torus mandibularis. Später untersuchten FARKAS und MARCSIK (1979) sowie FINNEGAN und MARCSIK (1979) an Serien aus der Awarenzeit das Auftreten einiger nicht metrischer Variationen (Torus mandibularis, doppeltes Foramen mentale, doppeltes Foramen mandibulare, Schluss des Mylohyoideusgrabens). Die Altersschrumpfung des Mandibulakörpers beschrieben PRÁGAI (1982) bzw. PRÁGAI und FAZEKAS (1982, 1983). TAMÁS (1986) studierte die Lage des Canalis mandibulae an Röntgenaufnahmen des Unterkiefers.

BOCSKAI (1908) studierte die Eigenarten des Gaumens am Oberkiefer. An 1200 Schädeln untersuchte HUSZÁR (1951) die Morphologie des Torus palatinus von der Awarenzeit bis zum XIX. Jahrhundert. LÁNG (1955) beschrieb die Formen des Canalis nasopalatinus seu incisivus, BOTTYÁN (1968, 1970, 1970a, 1971, 1974, 1974b) hingegen die unterschiedlichen Masse des Palatums, die Veränderungen im Laufe des Lebens, den geschlechtlichen Dimorphismus. FINNEGAN und MARCSIK (1979) studierten an Serien aus der Awarenzeit neben den oben erwähnten Charakteristika der Mandibula auch das Auftreten des Torus palatinus. PRÁGAI (1982) schrieb zu diesen Themenkreis seine Kandidatur.

KIEFERPATHOLOGIE

Die halbseitigen Entwicklungsanomalien des Unterkiefers beschrieb SOMOGYI (1953) auf Grundlage einer Untersuchung an 1000 Mandibulae, wovon 800 von Ausgrabungen stammen. Das Auftreten der idiopathischen Kieferhöhle von Stafne studierten FINNEGAN und MARCSIK (1980, 1981), MARCSIK (1983) sowie MARCSIK und KOCSIS (1985) an Serien aus der Awarenzeit.

Von den pathologischen Veränderungen des Oberkiefers beschrieben BERNDORFER (1962), REGÖLY—MÉREI (1970), MARCSIK (1976) bzw. KOCSIS und MARCSIK (1979) Fälle von Gaumenspalten. MARCSIK schrieb über die Kieferanomalien ihre Kandidatur (1983).

ZAHNANTHROPOLOGISCHE BESCHREIBUNGEN

ISZLAI (1881, 1881a) behandelte Gebisscharakteristika der Hauptrassen. Mit der zahnanthropologischen Beschreibung der Funde aus den Székesfehérvárer Königsgräbern befasste sich als erster TÖRÖK (1894), der eine ausführliche

Darstellung über die Kiefer BÉLAS III. gab. HILLEBRAND (1908, 1908a, 1909) führte seine Untersuchungen an 4100 Schädeln und 2000 Kiefern auch unter dem Gesichtspunkt der Zahnanthropologie durch. BARTUCZ (1914) schrieb über den Unterkiefer des Weimarer Urmenschen. MIHÁLY LENHOSSÉK (1922) beschrieb in seiner von Scheff redigierten Arbeit „Handbuch der Zahnheilkunde" die makroskopische Anatomie der Zähne, wozu er auch seine an Ausgrabungsmaterial gesammelten Erfahrungen verwendete. SALAMON (1923, 1938, 1940, 1940a, 1940b, 1941, 1942) beschrieb in seinen Veröffentlichungen die Gebisse von PETŐFI, FERENC LISZT, MARSCHALL ALVINCZY, der Frau von FERENC RÁKÓCZI II., des ungarischen Königs LAJOS II., König MÁTYÁS. JÓZSEF SZABÓ (1934, 1935) studierte die Mandibula des Urmenschen von Subalyuk, BARTUCZ (1935) hingegen schrieb eine Veröffentlichung über die Asche von FERENC RÁKÓCZI II. ALLODIATORIS (1937) arbeitete das Menschenmaterial der Friedhöfe in der Tiefebene aus der Árpádenzeit auf, MOLNÁR und HUSZÁR (1953) untersuchten in ihrer Studie über den stomatologischen geschlechtlichen Dimorphismus 100 Schädel. MALÁN (1955) berichtete über einen in der Höhle von Istállóskő gefundenen Zahnkeim, REGÖLY—MÉREI (1962) beschrieb Fälle normaler Dentition, THOMA (1963, 1966, 1967) hingegen beschrieb die Zähne des Subalyuker Kindes und des Vértesszőllőser Vormenschen. BARTUCZ (1966) gab beim Studium der exhumierten Überreste der ungarischen Jakobiner und von SEMMELWEIS eine Darstellung ihrer Gebisse, SCHRANZ (1988) veröffentlichte eine Beschreibung der Zähne von BÉLA III.

ZAHNKARIES

Die sich mit der Zahnkaries an fossilem Material befassende ungarische Literatur fassten HUSZÁR (1945), HUSZÁR und SCHRANZ(1952) und später ausführlich TÓTH (1970) zusammen. Die neben den anthropologischen Beschreibungen nebenbei aufgeführten Daten wurden in der vorliegenden Arbeit nicht berücksichtigt. An umfangreicherem, jedoch chronologisch gemischtem Material wurde die Karies auch von HILLEBRAND (1908, 1908a, 1909) untersucht. Die zweifellos bedeutendste erste Untersuchung der Zahnfäule in Ungarn ist mit dem Namen LENHOSSÉKS (1917, 1917a, 1918, 1919) verbunden, der — den in Frage gestellten Nagysáper Schädel ebenfalls eingerechnet — Schädel von der Urzeit bis zur allerneuesten Zeit untersuchte. SZIRÁKY und HUSZÁR (1933) fanden in ihrem Material aus der Árpádenzeit keine kariösen Zähne. HUSZÁR (1945, 1961, 1963, 1965, 1966, 1967, 1968) fasste die Kenntnisse über die Karies der Ungarn der Árpádzeit zusammen, er befasste sich gleichfalls mit dem Zahnmaterial des Fonyóder mittelalterlichen Friedhofes in Bezug auf die Verbindung Karies und Ernährung, Karies und Zahnabnutzung, sowie in Bezug auf die medizingeographie der Karies. KOLLÁR (1948) untersuchte unter diesem Gesichtspunkt das Material des Zengővárkonyer Eneolitenfriedhofes, BRUSZT (1950, 1952, 1958, 1966, 1975) wertete insgesamt 1128 Schädel und 367 herausgefallene Zähne von mehreren

Friedhöfen von VII. Jahrhundert bis zum XII. Jahrhundert aus. HUSZÁR und SCHRANZ (1952) untersuchten die Ausbreitung der Zahnfäule an der Bevölkerung in Transdanubien von der Neusteinzeit bis zur Neuzeit, SCHRANZ und HUSZÁR (1954, 1955, 1958, 1962) beschäftigten sich dagegen auch mit Kindergebissen in Funden der Urzeit. Vom Gesichtspunkt der Karies wurde Zahnmaterial von REGÖLY—MÉREI (1962) von der Neusteinzeit bis zur Árpádenzeit, von BRUSZT und KŐHEGYI (1963) von zur Zeit der Belagerung der Egerer Burg Gefallenen, BRABANT und NEMESKÉRI (1963) vom Friedhof der Hunnenzeit neben Mözs, KISZELY (1966) hingegen vom Longobarder Friedhof in Szentendre ausgewertet. TÓTH (1966, 1967, 1967a, 1967b, 1967c, 1968, 1970, 1970a) machte Kariesuntersuchungen an mehreren Serien aus der Bronzezeit, der Awarenzeit und der Árpádenzeit, später beschrieb er aufgrund seiner Erfahrungen und anderer ungarischer Kariesuntersuchungen das Erscheinungsverhalten der Krankheit in Ungarn von der Urzeit bis in unsere Tage. TÓTH und SONKODI (1972) studierten die Zähne des Tápéer Bronzezeitfriedhofes. Karies fanden ÉRY (1971, 1981, 1982) an Knochenüberresten der Bevölkerungen von Tengelic (10. Jahrhundert), Tokod (5. Jahrhundert) und Dombovár (Türkenzeit), ENDRÉSZ (1986) an menschlichen Überresten der Árpádenzeit, PAP (1986) hingegen an menschlichen Überresten mehrerer mittelalterlicher Serien. Zu diesem Themenkreis schrieben BRUSZT (1975) seine Kandidatur bzw. TÓTH (1967c) seine akademische Dissertation.

UNTERSUCHUNGEN ZUR ZAHNABNUTZUNG

MOLNÁR (1939) und später MÁTHÉ und MOLNÁR (1940) untersuchten den Abnutzungsgrad der Zähne von mehreren Hundert Schädeln von der Völkerwanderungszeit bis zum Mittelalter. KOLLÁR (1948) studierte gleichfalls unter diesem Gesichtspunkt Schädel aus der Zengővárkonyer Eneolithikum. HUSZÁR und SCHRANZ (1954) handelten die statistische Auswertung der Zahnabnutzung in Fällen von Knochenfunden ab, SCHRANZ und HUSZÁR (1954, 1955) dagegen bewerteten aus dieser Sicht 276 Erwachsenenschädel und Kinderschädel aus der Urzeit sowie die Zähne der Unterkieferreste von Istállóskő. REGÖLY—MÉREI (1962) studierten Zähne von Schädeln von der Neusteinzeit bis zum Mittelalter, BRABANT und NEMESKÉRI (1963) Zähne von Schädeln aus Mözs (Hunnenzeit). HUSZÁR (1963, 1968, 1972, 1974, 1974a) untersuchte die Abnutzung von Milchzähnen, die aus der Neusteinzeit bis zum Mittelalter stammen. Später wertete er dies zusammen mit dem eben erwähnten Material der Urzeit in seiner akademischen Dissertation (1976) aus. KISZELY (1966) betrachtete die Abnutzung der Zähne des Longobardenfriedhofes von Szentendre. SCHRANZ (1967) beschrieb unter dem Blickpunkt der Zahnabnutzung — neben Funden von österreichischen und deutschen Ursteinzeit — auch einzelne Funde von der ungarischen Ursteinzeit bis zum heute Lebenden. KOCSIS (1988) untersuchte die Abrasion der Milch- und bleibenden Zähne an Zahnmaterial des Gorzsaer neusteinzeitlichen Friedhofes.

PARODONTALE KNOCHENVERÄNDERUNGEN

KOLLÁR (1948) studierte an Zengővárkonyer eneolitzeitlichen Funden den Abbau des alveolaren Knochens, SCHRANZ und HUSZÁR (1954, 1955) dagegen werteten Knochenmaterial aus allen Phasen der Urzeit aus. SCHRANZ (1962) fasste die sich mit solchen Untersuchungen befassende ausländische Literatur zusammen. Er untersuchte 190 frühurzeitliche Gebisse bzw. 4 Gipsabgüsse fossiler Funde. REGÖLY—MÉREI (1962) beschreibt an einzelnen Funden von der Eisenzeit bis zum Mittelalter parodontale Veränderungen. BRABANT und NEMESKÉRI (1963) beschreiben das gleiche am Material des Mözser Hunnenfriedhofes. HUSZÁR (1963) bewertete an den Kiefern der Fonyóder spätmittelalterlichen Funde auch parodontale Veränderungen, TÓTH (1966a, 1966b) untersuchte an Schädeln der Awaren- und Árpádenzeit den Zustand des Processus alveolaris. BARTUCZ (1966) fand an ausgewähltem paleopathologischem Material in mehreren Fällen alveoläre Knochenveränderungen. ENDRÉSZ (1986) bewertete in seiner Diplomarbeit an Schädeln der Árpádenzeit die Zahnsteinbildung und die verschiedenen Formen der Veränderungen des alveolaren Knochenrandes.

PERIAPIKALE VERÄNDERUNGEN, FOLGEERKRANKUNGEN

In der Mehrzahl der sich mit Karies beschäftigenden Veröffentlichungen beschrieben die Autoren auch das Auftreten von Folgeerkrankungen (periapikale Entzündung, Zyste, Fistel usw.). Im folgenden werden die Veröffentlichungen, in denen dies zu finden ist, lediglich aufgezählt: LENHOSSÉK (1917, 1917a, 1918, 1919), KOLLÁR (1948), BRUSZT (1952, 1958, 1966), SCHRANZ und HUSZÁR (1954, 1955) BRUSZT und KŐHEGYI (1963), BRABANT und NEMESKÉRI (1963), HUSZÁR (1963), BARTUCZ (1966), TÓTH (1966, 1967a), ÉRY (1971, 1982), FARKAS und MARCSIK (1975), SZARVAS (1981), PAP (1986) und KOCSIS (1988).

ENTWICKLUNGSANOMALIEN

ÁRKÖVY (1904, 1904a) berichtet über Reduktionserscheinungen der Zähne bzw. über das sog. Tomes-Zsigmondy-Divertikulum, die Cingulumbildung an den oberen seitlichen Schneidezähnen und das „Foramen coecum" der Molaren am Material mehrerer geschichtlicher Epochen. HILLEBRAND (1908, 1908a, 1909) untersuchte an den Zähnen der schon erwähnten grossen Zahl Schädel Entwicklungsanomalien bezüglich der Zahl, Form und Aufbau, SALAMON (1912) hingegen beschrieb auch bei seiner Abhandlung der primären Stellungsanomalien der Zähne auch über Ausgrabungsfunde. MÉHELY (1925) studierte an ungarischen Funden prismatische (taurodonte) Zähne, RADÓ (1926) untersuchte die sich aus der phylogenetischen Reduktion des Unterkiefers und des Gebisses ergebenden Anomalien. HUSZÁR (1945, 1963) beschrieb Entwicklungsanomalien an Funden

aus der Árpádenzeit bzw. Fonyóder spätmittelalterlicher Zähnen. KOLLÁR (1948) fand an Zengővárkonyer Schädeln der Eneolithikum Zahnnichtanlage. BRUSZT (1950a, 1950b, 1953, 1953a, 1954, 1963, 1975) studierte an aus Ausgrabungen stammenden Zähnen die Ausbildung des „Dens in dente", die Zweiwurzeligkeit des oberen Milcheckzahnes und des bleibenden Eckzahnes, und fasste seine Ergebnisse 1975 in seiner Kandidatur zusammen. SCHRANZ und HUSZÁR (1954, 1955) erwähnen mehrere Fälle von Entwicklungsanomalien aus ihrem urzeitlichen Material. REGÖLY—MÉREI (1962) beschrieb Stellungsanomalien, Impaktierung an aus verschiedenen Zeiten stammenden Funden. BRABANT und NEMESKÉRI (1963) untersuchten die Milch- und bleibenden Zähne des Mözser Hunnenfriedhofes nach Entwicklungsanomalien, BARTUCZ (1966) dagegen erwähnt aus geprägte Zahnstellungsanomalien an einem Jazyg-Schädel. KISZELY (1966) studierte das Zusammenpassen der Zahnreihen und die Zahngrösse an Longobarden. FARKAS und MARCSIK (1975) beschrieben an mehreren urzeitlicheren Serien auch die Entwicklungsanomalien, sowie KOCSIS und MARCSIK (1979, 1980, 1981, 1982, 1983, 1983a, 1987) an Funden aus der Awarenzeit. SZARVAS (1981) studierte an Serien aus der Awarenzeit aus der Umgebung von Szeged das Tuberkulum Carabelli und die Erscheinung der Schaufelform der Schneidezähne. ÉRY (1981, 1982) untersuchte Zähne aus dem 5. Jahrhundert und der Türkenzeit, MARCSIK und KOCSIS (1984, 1986) Zähne aus der Awarenzeit. KOCSIS und TROGMAYER (1986) werteten die Zähne des Vésztőer neusteinzeitlichen und kupferzeitlichen Friedhofes aus. MARCSIK und BAGLYAS (1987) beschrieben Schmelzhypoplasien an Zähnen der Awarenzeit. KOCSIS (1988) untersuchte an Material des Gorzsaer neustenzeitlichen Friedhofes die Entwicklungsanomalien der Milch- und bleibenden Zähne. KOCSIS und MARI (1988) bewerteten die palatinal-gingivale Furchenbildung an neolithischen und awarenzeitlichen Serien, HAJÓS (1989) berichtet in ihrer Diplomarbeit über die Morphologie von 102 aus verschiedenen Zeitaltern stammenden zweiwurzeligen unteren Eckzähnen. Ausser der schon erwähnten Kandidatur von BRUSZT (1975) und der Diplomarbeit von HAJÓS (1989) schrieben auch SZARVAS (1981) und BAGLYAS (1986) eine Diplomarbeit, MARCSIK (1983) dagegen ihre Kandidatur zu diesem Themenkreis.

PSEUDOPATHOLOGISCHE VERÄNDERUNGEN, EXPERIMENTELLE UNTERSUCHUNGEN

RUDAS beschäftigt sich in seinen 1899 veröffentlichten Studien (1899, 1899a) mit den postmortalen Veränderungen des Knochens und der Zähne. PÓR (1948, 1953) sowie LÁNG (1964) und KOVÁCS (1972) benutzten Kiefer und Zähne als Volumenmessungs- bzw. röntgendiagnostische Objekte. Hier halten wir das Zitieren eines Details einer Veröffentlichung für wichtig, die KEMENES (1970) machte: „Wir fertigten von einigen Schädeln der Sammlung des Budapester Anthropologischen Institutes aus Anlass einer gründlicheren Untersuchung Röntgenaufnahmen an. Auf dem Röntgenbild der Mandibula des einen Schädels

fiel auf, dass in den völlig intakten Zähnen in den Wurzelkanälen ein wie eine Wurzelfüllung erscheinendes Material vorlag. Der überraschende und geheimnisvolle Röntgenbefund löste eine breite Nachforschung aus mit dem Ziel festzustellen, wann und wie das einen Röntgenschatten gebende Material in die völlig intakten Zähne des Unterskiefers gelangte. (...) Der frühere Direktor der anthropologischen Sammlung, Dr. JÁNOS NEMESKÉRI berichtete darüber, dass der fragliche Schädel einer von jenen Schädeln war, an denen Dr. LÁSZLÓ PÓR (1948) Quecksilbervolumenmessungen vornahm. (...) Das Quecksilber gelangte bei den Volumenmessungen — aufgrund seines grossen hydrostatischen Druckes — durch Verdrängen bzw. Zusammendrücken der Luft aus den Gebieten, wo organische Stoffe aufgelöst waren. (...) Die Klärung des veröffentlichten Befundes erforderte eine mühevolle Nachforschung und dient als Lehre all denen, die Museummaterial untersuchen. Es währe wünschenswert, zur Vermeidung von Missverständnissen, alle an den Schädeln durchgeführten Untersuchungen Zeitpunkt und Art im Tagebuch des Museums aufzuzeichnen."

SCHRANZ (1953) bewertete die Charakteristika von aus Ausgrabungen stammenden Zähnen aus gerichtsmedizinischer Sicht. LENGYEL (1964) sowie NEMESKÉRI und HARSÁNYI (1968) führten histologische, serologische, chemische Untersuchungen durch, bzw. untersuchten die postmortalen Veränderungen an solchen Zähnen. In diese bibliographische Gruppe nahmen wir auch jene Veröffentlichungen auf, die über Eingriffe aus wahrscheinlich kultischen Zwecken berichten, so die Mitteilung von BARTUCZ (1966) über den perforierten Unterkiefer von Füzesabony, und die Arbeit von JÓJÁRT (1988) über Wirkung der Schädeldeformierungen auf die Kiefer.

Buchauszüge über Untersuchungen, die an aus Ausgrabungen stammenden Kiefern und Zähnen durchgeführt wurden, sind uns von REGÖLY—MÉREI (1962) und KISZELY (1969) bekannt. Über die an den in Ungarn aufbewahrten 19 ägyptischen Mumien durchgeführten Zahnuntersuchungen berichteten REGÖLY—MÉREI und NEMESKÉRI (1958, 1958a).

MITTEILUNGEN AUSLÄNDISCHER AUTOREN ÜBER UNGARISCHE ZAHNFUNDE

BRABANT (1971) arbeitete — ausser dem bereits erwähnten Artikel von BRABANT und NEMESKÉRI (1963) — auch das Szabadszálláser Material der Skythenzeit auf. Eingangs wurden auch bereits die Veröffentlichungen von FINNEGAN und MARCSIK (1979, 1980, 1981) erwähnt. FRAYER (1984) sowie MOLNÁR und MOLNÁR (1985) arbeiteten Zahnmasse und Zahnpathologische Veränderungen aus vorgeschichtlichen Zeiten und aus dem ungarischen Mittelalter auf. In ungarischer Sprache berichten BRABANT (1962) und ANDRIK (1965) über eigene Untersuchungen.

Beendigung

Die aufgeführten Untersuchungen sind in vielen Fällen nur an aus Ausgrabungen zum Vorschein gekommenen Funden fortsetzbar. Teilweise stehen solche Kiefer und Zähne in grossen Mengen zur Verfügung, teilweise ist das Material nicht ausgewählt. Bekanntlich sind Knochen und Zähne aus Sectionssälen nicht geeignet, für eine wahre statistische Auswertung, weil die intakten Schädel von den Sectionshelfern mit Vorliebe präpariert werden. Die in den zahnärztlichen Einrichtungen entfernten Zähne sind wegen ihrer pathologischen Vorgeschichte ja extrahiert worden und oft so zerstört, dass sie für solche Untersuchungen ungeeignet sind. Das erklärt deshalb die ungebrochene Existens und Entwicklung der zahnärztlichen Paleopathologie und Paleoanthropologie.

Dieser Publikation wird dadurch Aktualität werliehen, dass zur Zeit der Institutsleitung durch Herr Professor PÁL LIPTÁK an meiner Arbeitsstelle, der Klinik für Zahnheilkunde und Kieferchirurgie, viele Kollegen paleoodontologische Untersuchungen durchführten. Im Namen meiner Kollegen TÓTH, PRÁGAI, SONKODI, FAZEKAS, ENDRÉSZ, JÓJÁRT, HAJÓS und in meinem eigenen Namen danke ich mit Hochachtung für diese Möglichkeit und die umfangreiche Hilfe während dieser Untersuchungen, welche wir damals beginnen und seitdem immer fruchtbarer fortsetzen konnten.

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ALTERSBEDINGTE VERÄNDERUNG DES GEHALTES MENSCHLICHER KNOCHEN AN ANORGANISCHEN SUBSTANZEN

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Zusammenfassung

In dem aus dem mittleren Anteil des Oberschenkelknochen der Leichen von 100 Personen der beiden Geschlechter (52 Männer und 48 Frauen) und unterschiedliches Alters (zwischen 13 und 89 Jahren) entommenen Proben wurden mit der atomabsorptions-spektrophotometrischen Methode die Konzentrationen der Elemente Ca, Na, K, Mg, Fe, Zn, Mn, Cu und Pb bestimmt.

Ein signifikanter Unterschied in der Konzentration der einzelnen Elemente in den einzelnen Altersgruppen: juvenil-adulte (13—50 Jahre), im Präsenium befindliche (51—65 Jahre) und im Senium (über 65 Jahre) bestand nicht ($P > 0.05$).

Schlüsselwörter: individuelle Lebensalter, anorganische Stoffe der Knochen, atomabsorpstions-spektrophotometrische Untersuchungen, forensische und historisch-anthropologische Forschungen.

Einleitung

In Verbindung mit der kriminalistischen Personenidentifizierung anhand von Knochenfunden sind die zuverlässigsten Daten bezüglich des Lebensalters unbekannter Personen aufgrund altersbedingter Besonderheiten der anatomischen Struktur der Knochen zu erhalten (BONTE et al., 1976; BURNY und WOLLAST, 1972; DE PUEG und BURDINE, 1972; FACCHINI und PETTENER, 1977; FÖLDES et al., 1980, 1981, 1982; HAMAGUCHI et al., 1975; HAYNES, 1968; HUNGER, 1978; KÓSA et al., 1982a, 1982b, 1988a, 1988b; MOSENBACH, 1974; RUBEZHANSKII, 1968, 1969).

Die gerichtsmedizinische und die historisch-anthropologische Praxis haben entsprechende Methoden zu der in solchen Fällen erforderlichen Lebensalterermittlung erarbeitet (BARKER, 1965; GOODE et al., 1972; GUSTAFSSON et al., 1974; SMOLIARINOV et al., 1966).

Das Lebensalter von menschlichen Feten und Neugeborenen lässt sich aufgrund der Knochenmasse ziemlich genaue bestimmen. Auch bis zum Pubertätsalter stehen dem Gerichtsmediziner zahlreiche Daten (körperliche Entwicklung, Zahnwechsel, Ossifikationsprozess, usw.) zur Verfügung. Meistens bedeutet die Altersbestimmung in Fällen von Erwachsenenskeletten das grösste Problem, während im Präsenium bzw. Senium das Häufigerwerden von Regressionsveränderungen wieder immer mehr Anhaltspunkte zur Ermittlung des Lebensalters bietet.

In der Fällen aufgefundener Knochenfragmente würde die Untersuchung der Knochen auf ihren Gehalt an anorganischen Substanzen einen neueren Aspekt zur Lebensalterermittlung bedeuten, da Literaturangaben zufolge die Konzentration der die Knochen aufbauenden anorganischen Elemente mit dem Lebensalter zusammenhängende Veränderungen (Zu- oder Abnahme) aufweist (BANZER et al., 1976; BARRY und MOSSMAN, 1970; BURNY und WOLLAST, 1972; HASSNER et al., 1967; HAYEK, 1967; HERRING, 1968; KÓSA et al., 1988a, PUUMALAINEN und UIMARIHUHTA, 1977).

Bei der Untersuchung des anorganischen Materialgehaltes der Knochen haben manche Autoren gefunden, dass die Konzentration einiger Elemente (z. B. Hg und Pb) mit fortschreitendem Alter in den Knochen steigt (JENSEN et al., 1972; KALASHNIKOV und ZSICKIK, 1977; KATRANOUSKOV und DGANKOV, 1972; KÓSA et al., 1980; MALTSEVA, 1973; TOUGAARD, 1973).

Aus gerichtsmedizinischer Sicht ware es in der Fälle von Skelettfragmenten oder einzelnen Knochen von sehr grosser Bedeutung, wenn aufgrund der chemischen Analyse einzelner Knochenstücke auf das Alter des unbekannten Individuums geschlossen werden könnte (BURNY und WOLLAST, 1972; KÓSA et al., 1980; 1988a; MADSEN, 1977).

Chemische Untersuchungen an historisch-anthropologischen Knochenmaterial haben in Ungarn LENGYEL (1964, 1967, 1968, 1969, 1970, 1971a, 1971b, 1971c, 1972a, 1972b, 1972c, 1976, 1979, 1980), LENGYEL und FARKAS (1972), LENGYEL und NEMESKÉRI (1963, 1964, 1965, 1970, 1972), LENGYEL und MISZKIJEWICZ (1974), NEMESKÉRI und LENGYEL (1963) durchgeführt.

Die atomabsorptions-spektrophotometrische Messung stellt heute bereits in vielen erreichbares Untersuchungsverfahren dar, das bei der Bestimmung des Gehaltes der Knochen an anorganischen Substanzen genaue Ergebnisse liefert. Nachdem die bisherigen diesbezüglichen Untersuchungen derartige Möglichkeiten und zuverlässige Resultate geliefert haben, beschlossen wir, die Frage anhand der Untersuchung eines umfangreichen Knochenprobenmaterials zu klären.

Untersuchungsmaterial und Methode

Aus dem Sektionsmaterial unsere Instituts wurden 100 Leichen der beiden Geschlechter (52 Männer und 48 Frauen) und verschiedener Alter (zwischen 13 und 89 Jahren) ausgewählt und aus dem mittleren Anteil des Oberschenkelknochens (aus der Kompakta) Proben entnommen und mittels atomabsorptionsspektrophotometrischer Methode ihr Gehalt an einer Gruppe anorganischer Elemente (Ca, Na, K, Mg, Fe, Zn, Mn, Pb, Cu) bestimmt. Die erhaltenen Ergebnisse wurden mathematisch-statitstich bewertet.

Zur Vorbereitung des Untersuchungsmaterials benutzen wir das teilweise modifizierte Verfahren von LE GANDRE und ALFREY (1976).

Dabei wurden die zu untersuchenden Knochenproben in der Knochenmühle zu 0.2—0.5 mm grossen Granula zerkleinert und dann mit 3 ml eines Aether-Alkoholgemisches 1:1 bzw. anschliessend 3 mal mit je 5 ml eines Petrolaether-Aethergemisses 1:1 gereinigt. Nach der Entfernung des Lösungsmittels wurden die Knochenproben bis zur Gewichtskonstanz getrocknet, von dem so gewonnenen Material 1 g in ein 50 ml fassendes Becherglas gemessen, 2 ml cc. suprapure Salzsäure und 1 ml cc. suprapure

Salpetersäure dazugegeben und am Wasserbad eingedampft. Die säurige Freisetzung wurde noch zweimal wiederholt.

Parallel mit dem Testmaterial wurden auch Blindproben angesetzt, wo nur die obigen Säuremengen eingemessen waren.

Die eingetrockneten Materialproben bzw. Blindproben wurden dann mit 0.2-%igem Lanthanchlorid quantitiv in 25 ml-Messkolben übertragen und aus dieser Stammlösung die zu den Messungen benötigten Verdünnungen bereitet. Die Messungen erfolgten mit Hilfe des Perkin Elmer Absorptions-Spektrophotometer Modell 306, unter den Fabrikvorschriften entsprechenden optimalisierten Bedingungen in der Luft/Azetylen-Flamme.

Ergebnisse und Besprechung

Tabelle 1. veranschaulicht die Mittelwerte der in der Femurdiaphyse gemessen Ca-, Na-, K-, und Mg-, und Tabelle 2 jene der Fe-, Zn-, Mn-, Pb-, und Cu-Konzentrationen nach Altersgruppen zwischen 13—50 Jahren (juvenil-adulte) zwischen 51—65 Jahren (Präsenium) und Senium (über 65 Jahre).

Bei der computergesteuerten mathematischen Bewertung fand Untersuchung des Mittelwertes, der Streuung, der Korrelation bzw. Regression der Altersgruppen

Tabelle 1. Veränderung des Gehaltes menschlicher Knochen an anorganischen Substanzen in mg/g mit dem Lebensalter

Alters-gruppe	n	Mittleres Lebensalter	Ca	Na	K	Mg
11—50	43	36,46	180,37	5,51	1,09	2,34
		± 10,07	± 18,04	± 1,52	± 0,54	± 0,33
51—65	23	57,86	186,56	5,55	0,73	2,25
		± 4,15	± 22,98	± 1,23	± 0,30	± 0,27
66—	34	75,79	188,41	6,16	1,12	2,33
		± 6.01	± 18,59	± 1,44	± 0,44	± 0,25
Insgesamt 100		P>0,05				

Tabelle 2. Veränderung des Gehaltes menschlicher Knochen an anorganischen Substanzen in µg/g mit dem Lebensalter

Alters-gruppe	n	Mittleres Lebensalter	Fe	Zn	Mn µg/g	Pb	Cu
11—50	43	36,46	41,20	118,67	3,02	15,90	5,03
		± 10,07	± 43,79	± 40,20	± 1,04	± 27,85 ± 3,80	
51—65	23	57,86	39,67	108,60	2,84	13,71	3,11
		± 4,15	± 41,80	± 21,31	± 1,00	± 7,12 ± 2,54	
66—	34	75,79	39,81	142,87	9,88	21,10	5,20
		± 6.01	± 32,87	± 106,95	± 0,95	± 19,39 ± 2,88	
Insgesamt 100		P>0,05					

statt und darüber hinaus wurde auch untersucht, ob zwischen den Altersgruppen ein signifikanten Unterschied besteht.

Im Sinne dieser Befunde war bisher bei keinem einzigen Element eine signifikante Abweichung zu registrieren.

STREHLOW und KNEIP (1969) hatten bei der atomabsorptionsspektrophotometrischen Untersuchung des Gehaltes der Zähne an anorganischen Substanzen beobachtet, dass das Pb mit fortschreitenden Lebensalter in zunehmender Konzentration anwesend ist (Tabelle 3, Diagramm 1).

Aufgrund der Analyse der Zähne von 57 unseren Sektionsmaterial entstammenden Individuen unterschiedlichen Alters und Geschlechts konnten wir die Feststellung der zitierten Autoren nicht bekräftigen (FÖLDES et al., 1981), da in den Zähnen mit zunehmenden Alter korrelierende Konzentrationszunahmen weder im Falle des Pb, noch bei anderen Elementen vorkamen (Tabelle 4 und 5). Für die gerichtsmedizinische Praxis eine Methode auszuarbeiten, mit Hilfe derer innerhalb der Verjahrungsfrist von Verbrechen aufgrund der Untersuchung der Knochen an anorganischen Substanzgehalt das Lebensalter einer unbekannten Person mit Sicherheit festgestellt werden könnte, ist somit bislang nicht gelungen.

Tabelle 3. Bleigehalt der menschlichen Zähne nach STREHLOW und KNEIP (1969)

Lebensalter	Blei µg/g Asche	im Mittel
—10	15 13 7 26 13	17 ± 1
10—20	32 13 15 72	22 ± 7
20—30	11 16	36 ± 10
30—40	65 36 65	59 ± 10
40—50	84 77 44	72 ± 13
50—60	169 75 96	116 ± 29

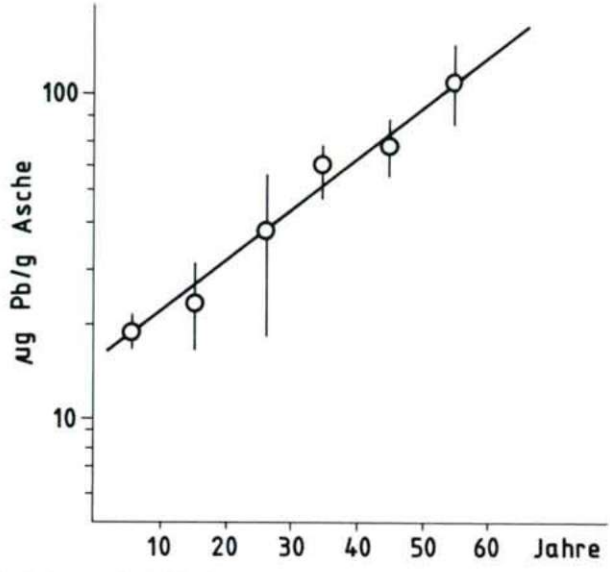

Abb. 1. Veränderung des Bleigehaltes menschlicher Zähne mit dem Lebensalter nach STREHLOW und KNEIP (1969)

Tabelle 4. Gehalt menschlicher Zähne an anorganischen Substanzen

	Ca	Na	K	Mg	Fe	Zn	Mn	Cu	Li	Pb
	mg/g Asche				mg/g Asche					
Frischer Femur, (100 Untersuchungen)	184,53 ± 19,60	5,75 ± 1,45	1,02 ± 0,49	2,32 ± 0,29	40,38 ± 39,53	124,58 ± 69,20	2,93 ± 0,99	4,67 ± 3,33	— —	17,25 ± 21,90
Zähne (57 Untersuchungen)	495,0 ± 157,8 P<0,05	9,15 ± 3,01	0,62 ± 0,13	10,36 ± 1,78	436,0 ± 304,3	613,0 ± 297,2	17,57 ± 11,1	24,62 ± 11,84	2,72 ± 0,98	— —

Tabelle 5. Gehalt menschlicher Zähne an anorganischen Substanzen nach Geschlechtern

	Ca	Na	K	Mg	Fe	Zn	Mn	Cu	Li	Pb
	mg/g Asche				mg/g Asche					
Frischer Femur (100 Untersuchungen)	184,53 ± 19,60	5,75 ± 1,45	1,02 ± 0,49	2,32 ± 0,29	40,38 ± 39,53	124,58 ± 69,20	2,93 ± 0,99	4,67 ± 3,33	— —	17,25 ± 21,90
Zähne (35 Untersuchungen)	507,00 ± 145,30	8,48 ± 2,89	0,61 ± 0,11	10,73 ± 2,0	487,00 ± 338,6	655,00 ± 314,3	18,57 ± 11,06	24,95 ± 10,9	2,71 ± 0,9	— —
Zähne (22 Untersuchungen)	483,0 ± 151,8 P<0,05	9,81 ± 2,98	0,63 ± 0,17	9,99 ± 1,7	385,0 ± 233,4	570,0 ± 232,5	16,57 ± 11,4	24,29 ± 13,2	2,73 ± 1,00	— —

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UNTERSUCHUNG DES GEHALTES VON AUS KRIEGS-MASSENGRÄBERN STAMMENDEN KNOCHEN AN ANORGANISCHEN SUBSTANZEN

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Zusammenfassung

Im kompakten und spongiösen Knochen von 6 verschiedenen menschlichen Skeletten aus Kriegs-Massengräbern wurde mittels atomabsorptionsspektrophotometrischer Methode die Konzentration einer Gruppe von anorganischen Elementen (Ca, Na, K, Mg, Fe, Mn, Cu, Pb) bestimmt.

In den ausgegrabenen Knochen ist der Anstieg des Fe- und Mn-Gehaltes auch im Verhältnis zu den physiologischen Werten enorm, er kann sogar ein 50-faches derselben erreichen, was 1/6 der in den Erdproben tatsächlich vor anderen Konzentration entspricht.

Die Änderung des Gehaltes der Knochen von über 15. Jahre ohne Sarg begrabenen Leichen an anorganischen Substanzen (besonders Fe und Mn) zeigt deutlich das chronologische Alter des Knochen an. Die Untersuchung dieser Elemente kann eine geeignete Methode zur Ermittlung des chronologischen Alters in der forensischen und paläoanthropologischen Forschung sein.

Schlüsselwörter: menschliche Knochen, chronologisches Alter, anorganischen Substanzen der Knochen, forensische und historisch-anthropologische Untersuchungen.

Einleitung

Aufgrund der quantitativ-chemischen Analyse der Knochen haben einige Forscher (FREMY, 1853; WIBEL, 1869) bereits im vergangenen Jahrhundert festgestellt, dass die Zusammensetzung rezenter und fossiler Knochen während ihres Verbleibs in der Erde sich proportional der Dauer ihres Liegens in der Erde ändert: die Menge der anorganischen Stoffe (EASTOE, 1956; KNIGHT, 1969) lässt mit der Zeit nach, während die der organischen (GANGL, 1936; KLEMENT, 1938; KNIGHT, 1969; KÓSA et al., 1980, 1982; LINDQUIST, 1959) zunimmt.

WEIBEL (1912) zog aufgrund der Veränderung des spezifischen Gewichtsverhältnisse der kompakten Knochensubstanz auf das chronologische Alter der Knochen.

Auf diesem speziellen Fachgebiet der forensischen und paläoanthropologischen Osteologie sind in früheren Jahren, aber auch in der letzten Zeit intensive Forschungen getätigt worden (BERG, 1962, 1975; BERG und SPECHT, 1958; CALSTRÖM und ENGSTRÖM, 1956; EVANS, 1963; FAZEKAS und KÓSA, 1978; FLEISCH, 1966; FÖLDES et al., 1980, 1982; FÖLDES und KÓSA, 1980).

Dessen ungeachtet ergeben sich betreffs der Feststellung des chronologischen Alters der Knochen auch heute noch zahlreiche praktische Probleme, da die

Veränderung des Gehaltes der Knochen an anorganischen Stoffen dem Einfluss sehr vieler Faktoren untersteht (HUNGER et al., 1968; HUNGER und LEOPOLD, 1978; RAESTRUP, 1926; RAMANN, 1905; ZIEGELMAYER, 1963).

Unsere an aus dem archäologischen Ausgrabungsmaterial des Anthropologischen Instituts der Attila-József-Universität Szeged stammenden Knochen angestellten Untersuchungen (KÓSA et al., 1982) haben erwiesen, dass die Veränderung des Mn-Gehaltes das chronologische Alter der Knochen gut anzeigt.

Chemische Untersuchungen an geschichtlichem anthropologischen Knochenmaterial haben Lengyel (1964, 1967, 1968, 1969, 1970, 1971a, 1971b, 1971c, 1972a, 1972b, 1972c, 1976, 1979, 1980), LENGYEL und FARKAS (1972), LENGYEL und NEMESKÉRI (1963, 1964, 1965, 1970, 1972), sowie LENGYEL und MISZKIJEWICZ (1974), NEMESKÉRI und LENGYEL (1963) durchgeführt. Die angewandten Methoden und die erhaltenen Ergebnisse sind aus fachlicher Sicht bedeutend.

Die in den Knochen von ohne Sarg beerdigten Leichen vor sich gehenden physikalischen Prozesse können also Anhaltspunkte für die Dauer der Begräbniszeit in der Erde, d. h. für das chronologische Alter der Knochen liefern (FÖLDES et al., 1980; FREMY, 1853; KÓSA et al., 1982; WEIBEL, 1912).

Die unter Kriegsverhältnissen verscharrten Leichen (in Einzel- oder Massengräbern) bilden eine besondere Gruppe der Erdbestattung (HUNGER, 1967; HUNGER und LEOPOLD, 1978; HUNGER et al., 1968). Nachdem hier die Zersetzungsvorgänge (das Vermoderung der Knochen) schneller vonstatten geht als wenn die Leiche in einem Sarg bestattet worden wäre, hielten wir es für angezeigt, auch Untersuchungen über dic Bestattungsform anzustellen.

Untersuchungsmaterial und Methode

Zur Untersuchung der Verwesung der Knochen von Leichen, die ohne Sarg beerdigt wurden, haben wir aus Massengräbern stammende Knochen ausgewählt, bei denen infolge der genauen Kenntnis des Beerdigungs- und Exhumierungstermins die Zeitdauer des Begräbnis sicher feststellbar war. Der Gehalt der Knochen an anorganischer Substanz (Ca, Na, K, Mg, Fe, Zn, Mn, Cu, Pb) wurde in kompakten und spongiösen Knochen von aus 6 verschiedenen Massengräbern stammenden Skeletten atomabsorptions-spektrophotometrisch bestimmt.

Zur Vorbereitung des Untersuchungsmaterials wurde das teils modifizierte Verfahren von LE GANDRE und ALFREY verwendet (KÓSA et al., 1980, 1982).

Dabei wurden die zu untersuchenden Knochenproben in der Knochenmühle zu 0.2—0.5 mm grossen Granula zerkleinert und mit 3 ml eines Aether-Alkoholgemisches 1:1 gereinigt. Nach Entfernung des Lösungsmittels wurden die Knochenproben bis zur Gewichtskonstanz getrocknet. Von dem so gewonnenen Material wurden Mengen von je 1 g in 50 ml fassende Bechergläser gemessen, mit 2 ml cc. suprapurer Salzsäure und 1 ml cc. suprapurer Salpetersäure versetzt und im Wasserbad eingedampft. Die säurige Freisetzung wurde noch einmal wiederholt. Parallel mit den zu testenden Materialen wurden auch Blindproben angesetzt, welche nur die obigen Säuremengen enthielten.

Die eingetrockneten Materialproben wurden anschliessend — ebenso auch die Blindproben — mit 0.2-%iger Lanthanchloridlösung quantitativ in 25 ml-Messkolben übertragen und dann aus dieser Stammlösung die entsprechenden Verdünnungen bereitet.

Die Messungen erfolgten mit dem Atomabsorptions-Spektrophotometer Perkin Elmer Modell 306 unter den Fabrikanweisungen entsprechend optimalisierten Bedingungen in der Luft/Azetylenflamme.

Ergebnisse

Die Untersuchungsergebnisse bezüglich des anorganischen Substanzgehaltes der Knochen von ohne Sarg beerdigten Leichen sind in Tabelle 1. zusammengefasst.

Die Konzentration der in den Knochen untersuchten Elemente wechselte im Verhältnis zu den physiologischen Werten der Knochen in sehr unterschiedlichem Masse.

Die Ca-Veränderung bewegt sich innerhalb der physiologischen Wertstreungen. Der Mittelwert der übrigen Elemente hingegen weicht signifikant von den physiologischen Konzentrationen ab. Natrium und Kalium liegen unterhalb des physiologischen Wertes. Da es sich um verschieden lange Zeit in unterschiedlichen Bodenarten (12—15 Jahre) begrabene Leichen handelt, ist es auffallend, dass in der Fällen aller 6 Skelette der Na- und der K-Gehalt die in den Knochen normalerweise nachweisbare Konzentration nicht erreicht. Der Wert des Na hingegen liegt etwas höher als die in den Erdproben bestimmte Na-Konzentration. Bemerkt sei, dass wir bei diesen Knochenuntersuchungen nicht die tatsächlich die Knochen umgebenden Erdproben verwendeten, da sie ja nicht zur Verfügung stand und auch nachträglich nicht zu beschaffen waren, sondern die Mittelwerte zahlreicher Bodenproben berücksichtigten. Auch der K-Gehalt der untersuchten Knochenproben war im Vergleich zur Erdprobe in jeden Fällen niedriger. Die Veränderung des Mg-Gehaltes zeigte keinerlei Regelmässigkeiten in Bezug auf das chronologische Alter. Im Verhältnis zur physiologischen Konzentration war im Mg-Gehalt eine geringgradige Abweichung zu verzeichnen, doch war auch diese nicht signifikant ($P>0.05$).

Die Abweichung der Cu- und Pb-Konzentrationen von der physiologischen Werte und von der Konzentration der Probe ist ebenfalls keine bedeutende.

Die Erhöhung des Zn-Gehaltes, das Doppelte der noch höhere Werte betragen kann als physiologischerweise, ist mit einer Bodenverunreinigung (mit der Wirkung von gleichzeitig mit der Beerdigung in den Boden gelangten verunreinigenden Metalle zu erklaren).

Beachtlich ist dagegen der Anstieg des Fe- und Mn-Gehaltes in den ausgegrabenen Knochen. Der Fe-Gehalt kann unseren Untersuchungen zufolge sogar eine Erhöhung auf das 50-fache erreichen, d. h. 1/6 der in der Bodenprobe anwesenden Konzentration.

Nach 15-jährigem Liegen in der Erde kann auch der Mn-Gehalt ein 50-faches des physiologischen Wertes erreichen, was etwa 50% der in der Erdprobe nachweisbaren Menge entspricht.

Diese Veränderungen sind so zu bewerten, dass in Fälle einer Exhumierung binnen 15 Jahren die Veränderung des Mn-Gehaltes der Knochen den besten „Indikator" zur Ermittlung des chronologischen Alters der Knochen darstellt.

Tabelle 1. Der Gehalt der Knochen von ohre Sarg beerdigten Leichen an anorganischen Substanzen

Fall Nr.	Fundort	Verweildauer in der Erde (Jahre)	Untersuchungs-material	Ca	Na	K	Mg	Fe	Zn	Mn	Cu	Pb
				mg/g				mg/g				
			Mittelwert der Bodenproben (n = 100)	83,0	1,90	2,20	19,0	129,90	59,0	335,0	19,0	8,0
				184,53	5,74	1,02	2,31	40,38	124,58	2,93	4,67	17,25
			Mittelwert frischer Knochen (n = 100)	± 19,60	± 1,45	± 0,48	± 0,29	± 39,53	± 69,20	± 0,99	± 3,33	± 21,90
1.	Massengrab bei Doboz	12	Mittelwert von Femur, Mandibula, Clavicula	184,0	2,43	0,38	1,23	239,0	210,0	61,33	6,87	9,0
2.	Exhumierung (M. B.) ca 60 Jahre	14	Mittelwert von Mandibula, Dens, Clavicula	215,0	4,02	0,26	2,39	553,0	254,0	16,73	19,47	33,0
3.	Massengrab bei Székesfehérvár	15	Mittelwert von Femur und Sternum	199,0	3,97	0,78	3,00	855,0	419,0	81,00	68,4	13,5
4.	Massengrab in Komitat Fejér	15	Mittelwert von Femur u. Sacrum	154,0	1,12	0,59	2,12	975,0	156,0	62,6	7,1	4,0
5.	Massengrab su dem II. Weltkrieg	15	Mittelwert von Femur u. Mandibula	208,0	3,07	0,68	1,88	250,0	331,0	113,8	10,95	9,0
6.	Ein unbekannter russischer Soldat	15	Mittelwert von Femur und Calcaneus	226,0	3,40	0,53	2,05	117,0	208,0	176,0	15,65	28,0

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THE OCCURRENCE OF BONE TUMORS IN THE ANTHROPOLOGICAL REMAINS BELONGING TO THE SZÉKKUTAS-KÁPOLNADŰLŐ CEMETERY (HUNGARY) OF THE LATE AVAR PERIOD

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Abstract

During the paleopathological examination of 518 human skeleton remains belonging to the Székkutas-Kápolnadűlő cemetery (Hungary, territory east of the river Tisza) of late Avar (8th century) and Sarmatian period, the autor noticed the traces of tumorous lesion on 16 individuals. Most of them were consequences of benign tumorous diseases: osteochondromas in 7 and osteomas in 6 cases. We have to accentuate that malign tumors occurred in 3 cases: in one case a multiple myeloma and in two cases metastatic carcinoma were the presumable diseases. The differential diagnosis was made by examinations using macroscopic morphological, X-ray and scanning electron microscopes.

Key words: paleopathology, Avar period, osteochondroma, osteoma, multiple myeloma, metastatic carcinoma.

Introduction

There are known several ways of classifying the tumors of bone both in the recent and in the paleopathological literature. All of them, however, agree in the principle of separating the primary tumors from the secondary (metastatic) ones (ORTNER and PUTSCHAR, 1981; BARTA, 1986). In case of primary tumors the authors of recent papers, besides a simple separation of the individual benign and malign diseases (PARSONS, 1980; ZIMMERMAN and KELLEY, 1982), consider the process how the different tumor types were developing in and from the tissues (STEINBOCK, 1976; GLAUBER et al., 1980; ENDES, 1983; REVELL, 1986). Most of them take as a basis the classification of 1971 by SPJUT et al., and following it, separate each others tumors of cartilage, bone, fibrous, medullary and vascular origins.

The analysis of bone tumors is one of the most difficult problem in the paleopathology. The tissue elements of the tumors, excepting a special part of the ossifying tumors, vanish together with the viscera and, consequently, their identification becomes impossible. When historical anthropological remains are examined generally the larger structural changes (pathological hypertrophy or hypotrophy of the bones) give the necessery information. These examinations, however, excepting a few relatively unambiguous diagnoses (osteoma eburneum, osteochondroma, osteosarcoma osteoplasticum) mostly cause differential

diagnostical problems. There are, namely, several infectious or metabolic changes which cause processes involving bone production. In case of osteolytic phenomena the postmortal origin or the suspicion of different infectious diseases are reasonable suppositions. Further difficulties may be caused by the separation of tumors involving similar osteologic symptoms (e.g. multiple myeloma, osteolytic metastasis, multiple eosinophile granuloma).

Nevertheless, in the paleopathological literature of the recent years one may experience vivid interest regarding the tumorous lesion detectable in historical anthropological series (SOULIÉ, 1980; LOBDELL, 1981; CYBULSKI and PETT, 1981; TKOCZ and BIERRING, 1984; STROUHAL and VYHNANEK, 1981, 1987; GREGG and GREGG, 1987; GRUPE, 1988). The separation of the tumor types has been facilitated by the development of the differential diagnostical processes (UHLIG, 1982; SCHULTZ, 1986).

Materials and methods

The subject of the examination consisted of the anthropological remains of the Székkutas-Kápolnadűlő cemetery of late Avar and Sarmatian period stored in the collection of the Department of Anthropology, Attila József University. During the period 1965—1986 altogether 555 graves were explored under the direction of archeologist KATALIN B. NAGY, and 533 of them can be dated from the Avar Period.

Skeletal remains of 518 individuals were dug out of those graves. Most of them were fragmentary (66,8%) or in a middling preservation (24,5%).

The aim of our work was to assess the pathological changes detected on the remains of the late Avar period (8th century). That assessment was carried out together with the determination of sexes and ages at death by using macroscopic morphological methods and taking the corresponding special literature into consideration.

For identifying the pathological cases and, especially, for carrying out the more difficult differential diagnosis, it was necessary the use of X-ray analysis, as well as the adoption of stereomicroscopic and scanning electronmicroscopic examinations.

Discussion

When the examinations of the late Avar period remains were carried out, besides other disease types, tumors of bone of different origin and appearance also occured. Among them we could differentiate lesions of chondrogen, myelogen and metastatic origins.

Among the examined remains in seven cases the occurrence of osteochondroma was detected as a representative form of the tumors of chondrogen origin. The most frequent benign tumor of bone is the osteochondroma or exostosis cartillaginea: a bone formation with a growing cartilaginous apex (ZIMMERMAN and KELLEY, 1982). The occurrence of this variety can be noticed in all cases where there is an enchondral ossification. It originates, however, mostly in the metaphysis of tubular bones. GLAUBER (in BARTA, 1986) classifies it as a type of semimalign

hamartomas. All the examined cases were 5—10 mm long, pin-shaped exostoses having their origins in the metaphysis of long bones (3 tibiae, 2 humeri, 2 fibulae, 1—1 radius and femur). Division according sexes and ages at death was, as follows: 1 adult female, 3 adult males and 3 mature males.

Regarding the tumors of osteogen origin the occurrence of osteoma was detected at 6 individuals. The benign tumor consisting of mature bone tissues was to be noticed almost in all cases on the skull bones, and could be classified as a type of the benign hamartomas (GLAUBER et al., 1980). The observed cases were so called „button" osteomas of 3—8 mm diametres. They occured in 4 cases on the surface of tabula externa, in one case on the surface of the tabula interna and in one case on that of the angulus mandibulae (Fig. 1.). The lesions were distributed among one adult female, three mature females, one senile female and one adult male. One has to separate from the osteomas the exostoses of thorn- or crest-formation originating in periosteum which usually were caused by inflamed, traumatic or other metabolic influences (ENDES, 1983).

By the following three cases of malign tumors may be aroused absolutely more interest than by the frequent changes of chiefly benign tumors.

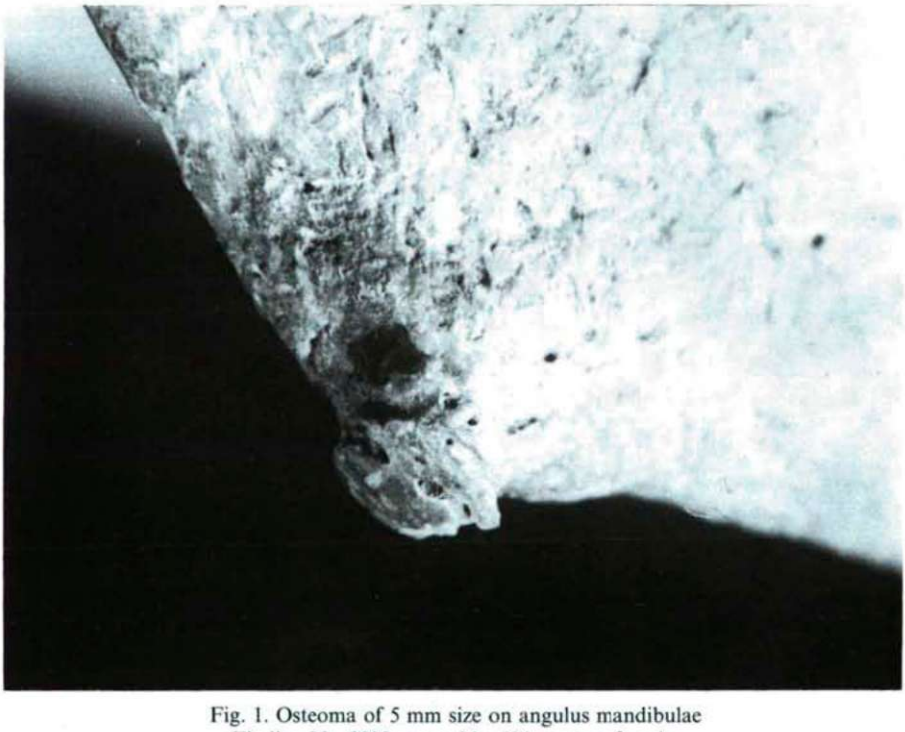

Fig. 1. Osteoma of 5 mm size on angulus mandibulae
Finding Nr. 9902, grave Nr. 524, mature female

— 1st case: grave Nr. 135 (number of finding: 8270). Fragmentary skeleton of a mature male. Several small osteolytic lesions usually of 3—6 mm diametres can be observed on the outer surface of the os frontale and on that of the right and left side os parietale (Fig. 2). The largest lesion (10x11 mm) can be seen on the surface of the left side os parietale. It has been probably caused by the fusion of three smaller foci into one spot. The smaller lesions have a shape of a regular circle. The shapes of the larger ones are not so regular. Most of those lesions perforated only the tabula externa, but a few of them completely perforated the vertex. When viewing from direction of the tabula interna one can see on the left side os parietale one and on the right side os parietale 4 smaller lytic areas. On the internal surface of the os frontale no lesion is to be seen.

Around the lesions no reaction of bones were to be seen neither with macroscopic nor with stereomicroscopic examination. No similar lesion has been detected by us on the very fragmentary frontal skull and postcranial skeleton. On can see cribra orbitalia in orbita sinistra and caries on molars 36 and 37.

On the X-ray photographs of the vertex (Fig. 3) we can see several lytic area to be found only in the diploë. No one of those lytic areas have broken through, however, any of the tabulae.

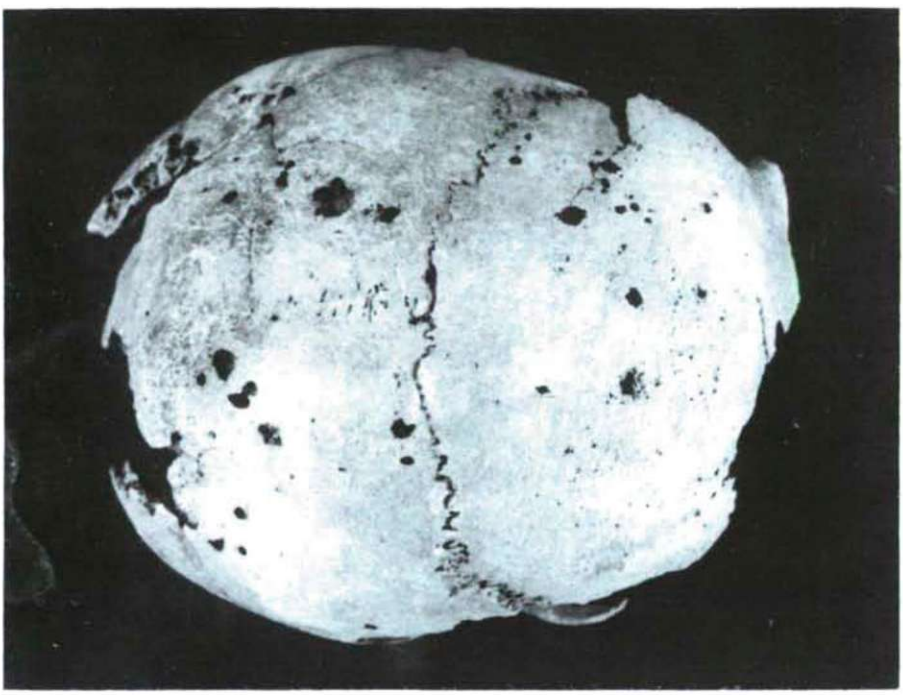

Fig. 2. Osteolytic lesions on the vertex
Finding Nr. 8270, grave Nr. 135, mature male

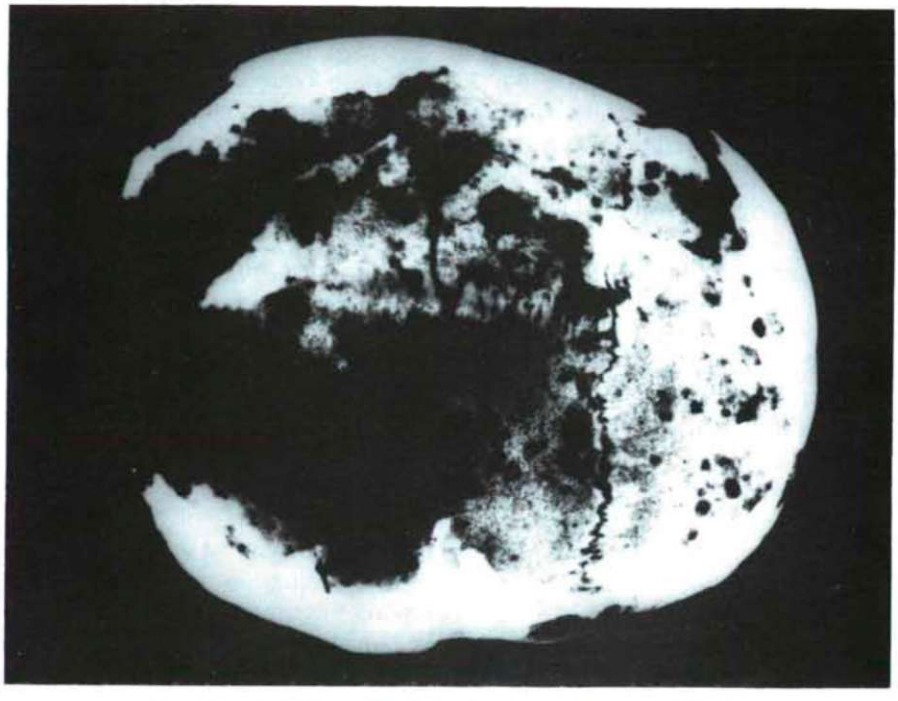

Fig. 3. X-ray photograph of the calvarium to be seen on Fig. 2.
Finding Nr. 8270, grave Nr. 135, mature male

During the paleopathological analysis of the osteolytic processes it was always the suspicion of postmortal origin that first emerged. That suspicion was, however, disclosed by the presence of the lesion localized to the diploë only, to be seen very distinguishably in the X-ray photographs chiefly on the right side of the os frontale.

When the morphological analysis is carried out for making diagnosis both the osteolytic metastatic carcinoma and the multiple myeloma (plasmocytoma) may be a reasonable supposition. Both diseases occur generally at individuals belonging to the age group over 50 years with similar localization (ORTNER and PUTSCHAR, 1981) because both of them prefer the flat bones containing active red medulla even at higher ages. Nevertheless, according to data to be found in the special literature, the multiple myeloma occurs more frequently on the vertex (STEINBOCK, 1976). In cases of multiple myeloma no sclerosis can be detected around the lesion and, consequently, the lysis is of punche-out character without condensation on the edges (ZIMMERMAN and KELLEY, 1982; ENDES, 1983; CSÁKÁNY and FORRAI, 1984). These statements can be proven by our X-ray photographs, too. The defects of similarily „perforated" character caused by eosinophil granuloma (histiocytosis X) are usually larger, and the disease mostly occur before the twentieth year of life. Consequently, it can probably be disclosed (GLAUBER et al., 1980). The high

number, the small diametre and the constant measure are characteristic to the multiple myeloma (UHLIG, 1982).

But in the case of the grave Nr. 135 the probability of osteolytic metastatic carcinoma may not completely be disclosed. Although the character of the defects can be chiefly compared to the case Nr. 4 (Abusir 204/h/78) described by STROUHAL and VYHNANEK (1981, 1987) their localization rather makes the multiple myeloma of myelogen origin probable which caused the death of the mature male with a great probability.

It is worth to mention the cribra orbitalia to be seen in orbita sinistra which could be caused by anaemia because of iron insufficiency (STUART-MACADAM, 1987). A connection can be supposed between these two processes because the damage of red medulla (both multiple myeloma and osteolytic metastasis) can cause production of haematopoietic problems. The common occurrence of cribra orbitalia and osteolytic tumor was announced by STROUHAL in two cases (1976—1977).

— 2nd case: grave Nr. 209, (number of finding: 8338). Skull and postcranial remains of a senile female. Despite the very fragmentary state of the bones several osteolytic defects can be detected. A lesion of 18x20 mm can be seen on the left side os parietale above the sutura sphenoparietalis and another one of 9x7 mm on the os occipitale. 2 larger lesions of 12—14 mm diametres have merged into a larger one on the left side os temporale, one lytic area of 6x5 mm can be seen on the os frontale and three smaller lytic areas 2—3 mm each can be seen on the same bone. The defects extend to both tabulae and the diploë the observed lesion. An osteolytic process can be observed on the mandibula, in several ribs and in the vertebrae.

By using a stereomicroscope or, especially, a scanning electronmicroscope we can observe that the defects on the vertex are notched, their edges are toothed. The lesions to be seen on the os occipitale and on the os frontale show on their edges a sclerotic formation of new bones (Fig. 4 and 5).

On the postcranial skeleton, in the right os ilium we can observe larger (29x19 mm) and in the vertebrae thoracales and lumbales smaller (5—7 mm) lesions. They have round shapes, notched edges. The lesions to be seen on the ribs penetrate through the cortical only in a diffuse manner (Fig. 6). Over the extensions of the cortical subtances we can see macroscopically and by scanning electronmicroscopes several spongiosa-like new bone tissues (Figures 7 and 8).

The X-ray photographs show over the intact area of the os frontale a lesion localized to the diploë. On the right side os ilium we can see three destructions originating in separate foci similarily to the other finding of the Avar period described by REGÖLY—MÉREI (1962). On the remains of the senile female from the grave Nr. 209, besides the lesions mentioned above, we can observe medially severe arthrosis deformans of both cubital articulations, a healed fracture of the right metacarpus 2 and an abcessus periapicalis and odontogenic fistula around the premolar 35.

The bone reactions and the lesions localized to the diploë disclose the supposition of postmortal origin. On the basis of the age at death and the

Fig. 4. Lytic area of 4x7 mm on os occipitale (5x)
Finding Nr. 8338, grave Nr. 209, senile female

localisation both the metastatic carcinoma and the multiple myeloma are reasonable assumptions. The latter, however, can be abandoned based on the differring sizes of the lesions, on their sclerotic edges and on the formation of osteoplastic substances, respectively (ORTNER and PUTSCHAR, 1981).

There are numerous kinds of primary tumors which can cause metastases in bones by haematogenic or lymphogenic diffusion. Most frequent of them are the metastases caused by mammary, prostatic, pulmonary, kidney and thyroid cancers (SPJUT et al., 1971). In the paleopathological examinations it is very difficult to make conclusions regarding the primary tumors because of lacking the soft tissues. According to the literary data the osteolytic-osteoplastic mixed metastases are mostly caused by mammary (SPJUT et al., 1971), mammary or prostatic (CSÁKÁNY and FORRAI, 1984; BENDER, 1987) and pulmonary (ORTNER and PUTCHAR, 1981) cancers. In similar metastasis regards SCHULTZ (1986) in his work the prostatic carcinoma the probable cause. GRUPE (1988) presents very similar lesions on the pelvis and ribs of a 40—50 years old male. He assumes that those lesions are of bronchogenic origin, and supports his results with microelement analysis. In our case the sex of the examined individual discloses the possibility of prostatic cancer. We can make the possible assumption, indeed, that the senile female suffered a

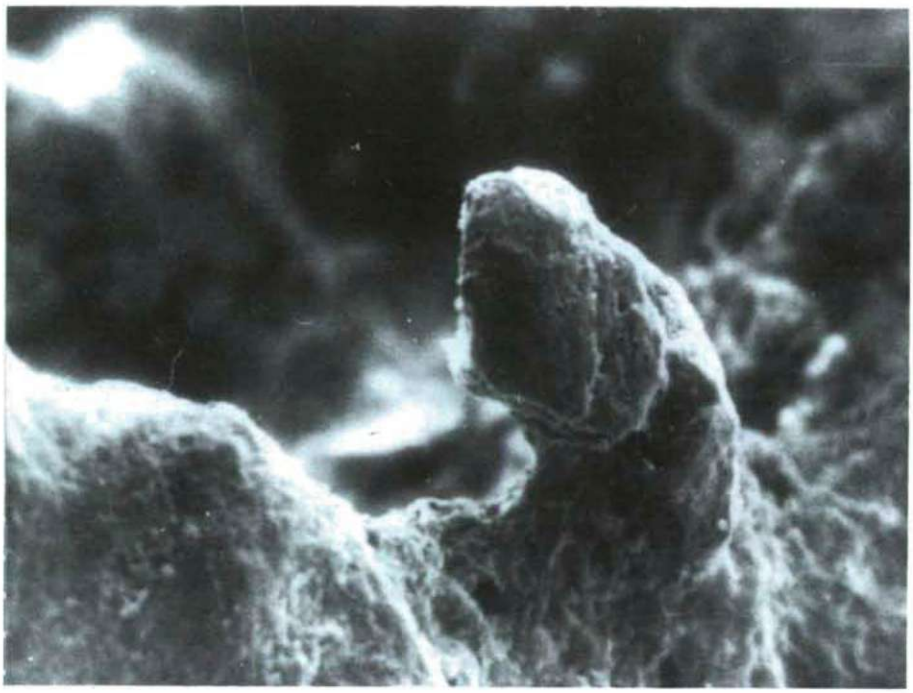

Fig. 5. A part of the sclerotic edge to be seen on Fig. 4. (180x)
Finding Nr. 8338, grave Nr. 209, senile female

pulmonic or laryngeal cancer but the possibility of a mammary cancer can't be disclosed either.

— 3rd case: grave Nr. 305 (number of finding: 11567). A fragmentary postcranial skeleton and a skull in a middling preservation belonging to an adult female. Numerous lytic lesions can be observed on the corpores of the vertebrae belonging to the upper thoracic region and on the ribs, respectively, as well as on the areas of caput and tuberculum costae. The sizes of the lesions are 2—11 mm, and because of their high number on a few vertebrae they take up the larger part of the substancia spongiosa (Fig. 9). Already a macroscopic examination clearly shows that a new compacta-like bone substance has been formed in the place of the original substancia spongiosa around the lytic areas.

No other osteolytic or other pathologic changes can be seen on the skull or on the other bones of the postcranial skeleton. We can observe even traces of lytic foci extending to the substancia spongiosa on the X-ray photographs of the ribs (Fig. 10).

The postmortal origin may be refused by a reasoning similar to that of the 2nd case. On the corpores of the vertebrae we can see that the intervertebral discus was not destroyed during the individual's life and, consequently, the spondylitis

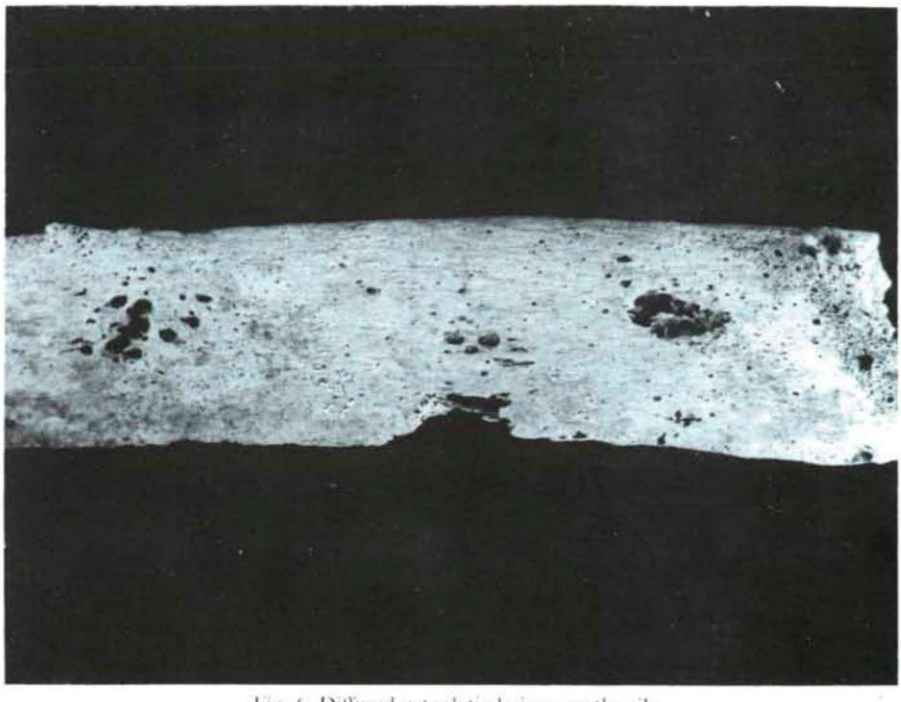

Fig. 6. Diffused osteolytic lesions on the rib
Finding Nr. 8338, grave Nr. 209, senile female

tuberculosa can be disclosed. Similar pathography can be caused by multiple myeloma often localized to vertebrae and ribs either (CYBULSKI and PETT, 1981) but in those cases the edge of lysis is not in a phase of condensation and no sclerosis can be found around it (GLAUBER et al., 1980; OLÁH, 1987). At his age of life (25—35 years old) the occurrence probability of multiple myeloma is very slight (UHLIG, 1982). We have more data regarding the occurrence of metastatic carcinoma at younger ages although that disease more often occurs at older ages (ORTNER and PUTSCHAR, 1981; UHLIG, 1982). The destruction of vertebrae described in the 3rd case can far mostly compared to the lesions to be seen on the thoracal vertebrae of the 30—35 years old Pueblo Indian female (PM 59834) described by HOOTON in 1930 (STEINBOCK, 1976).

Based on the character of the lytic foci, the sclerosis of the tabeculae and the localization, similarily to the case published by ORTNER and PUTSCHAR (1981) on the basis of the pathological anatomy's material (FPAM 5697), mammary carcinoma can be assumed as the probable cause. Because of the cystic character of the metastasis, a metastatic carcinoma of kidney or thyroid origin cannot be disclosed either (BENDER, 1987).

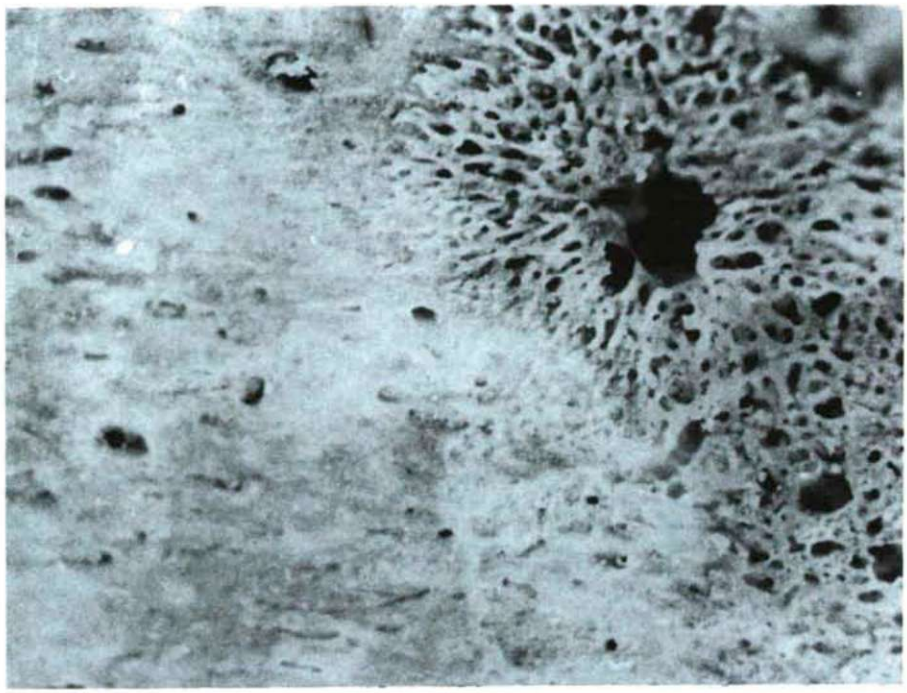

Fig. 7. Osteoplastic metastasis on rib surface (14x)
Finding Nr. 8338, grave Nr. 209, senile female

Conclusions

During the paleopathological examinations of the late Avar period skeleton remains belonging to the Székkutas cemetery in 16 cases was noticed the occurrence of neoplasms (3,08%). That value does not differs significantly from GLADYKOWSKA-RZECZYCKA's data (1988). She mentions the occurrence of tumors regarding the 2584 skeleton remains found in Czechoslovakia in 60 cases (2,3%) and regarding the 2666 skeletons found in Poland in 51 cases (1,9%).

The osteochondroma is the most frequent tumorous lesion of bones even in recent populations (GLAUBER et al, 1980). The frequency in paleopathology of the likewise frequent osteomas was experienced by KELLEY in the different remains between 0,5 and 3,7% (in: ZIMMERMAN and KELLEY, 1982).

We have emphasize among the tumorous lesions the occurrence of the three malign tumors. Their frequency in the sample of Székkutas (0,57%) is very similar to the occurrence of malign neoplasms (0,59%) in the Avar period remains found in Bačka-Topola (FARKAS and MARCSIK, 1979) but significantly lower than the occurrence experienced in the Egyptian sample (1,4%) published by STROUHAL and

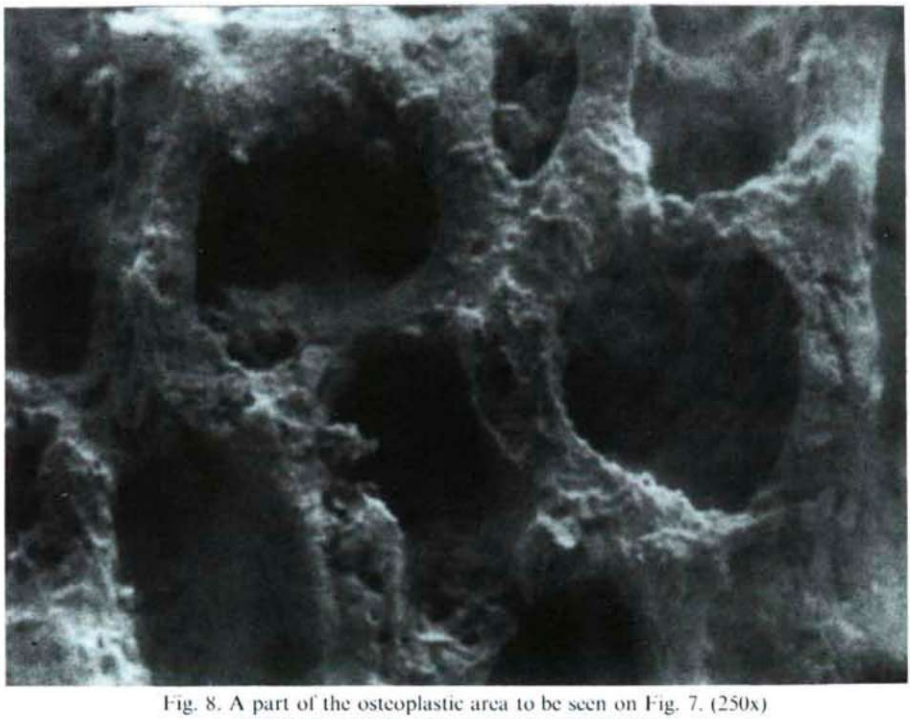

Fig. 8. A part of the osteoplastic area to be seen on Fig. 7. (250x)
Finding Nr. 8338, grave Nr. 209, senile female

VYHNANEK (1981 and 1987) and than the frequency observed by BLONDIAUX (1984) in the remains found in Northern France (4,1%).

The primary malign tumors occuring on the bones represent only 1—1,5% of all the malign processes (ENDES, 1983). The metastatic bone tumors are, however, much more frequent: according to the clinical data 12—17% of the malign tumors can cause metastases in bones (STEINBOCK, 1976; ORTNER and PUTSCHAR, 1981). Taking the above-mentioned data into consideration and basing on the data referring to the present population, i. e. in 1986 20,31% of the death cases were caused by cancer in our country (ECKHARDT, 1989), one could expect the occurrence of metastases in the examined skeleton remains in a higher percentage. There are several assumptions to explain why the actual facts differ from these expectations:

— the average lifetime of the Avar period population was lower than the lifetime for the time being, and the metastatic carcinoma usually developes at higher ages;

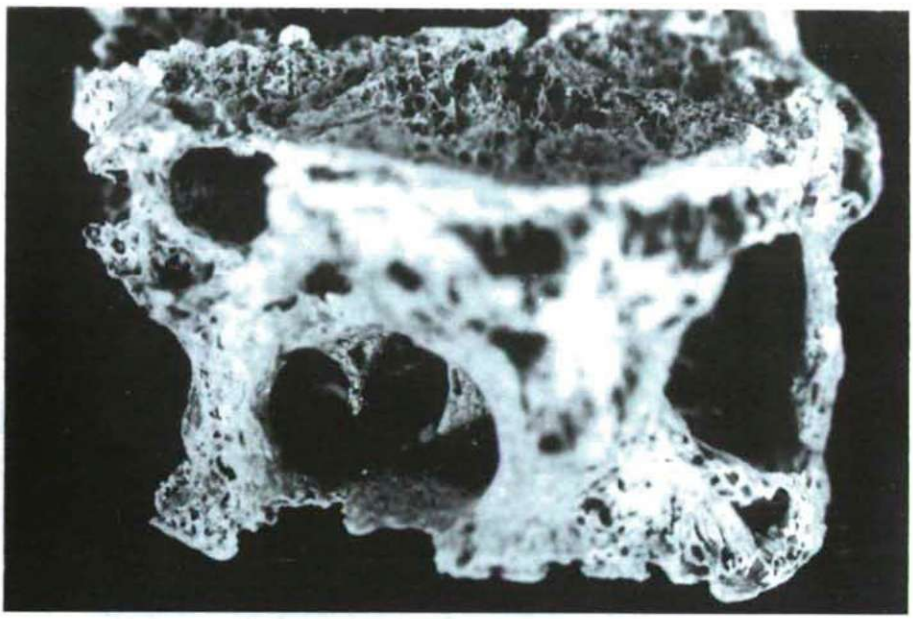

Fig. 9. Osteolytic lesions on a thoracic vertebra
Finding Nr. 11567, grave Nr. 305, adult female

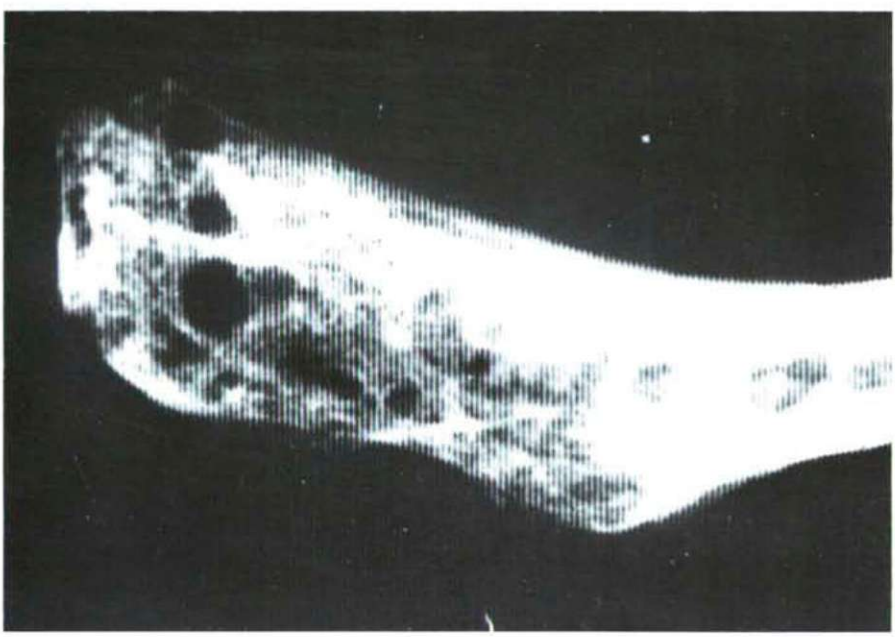

Fig. 10. Lytic foci on the X-ray photograph of the rib
Finding Nr. 11567, grave Nr. 305, adult female

— the well known cancerogenic environmental factors much less endangered the Avar population living 1200 years ago;

— because of the unfavorable and fragmentary preservation of the remains of Székkutas several lesions might have remained undetectable during the examinations.

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REFERENCE VALUES ON HISTORICAL ANTHROPOLOGICAL SKULL SAMPLES FOR PLANNING OF MANDIBULAR REPLACEMENTS (METHODOLOGICAL CONSIDERATIONS)

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Abstract

36 reference points and two contours on historical anthropological mandibles, and methods for the determination of their dimensions, are reported. Measurements have been made on 528 mandibles and will be evaluated for a computer data bank. The measurement data will be classified and averaged by computer and will be used for the planning of a series of mandibular replacements. Mandibles with average sizes will be selected from an anthropologically processed collection, and impressions of these taken for the preparation of wax models, the final refinements of which will give the actual series of mandibular prostheses. The data bank may also be used for the planning of dental implants better fitting the anatomical conditions. Accordingly, the practical aims and methodological considerations for their achievement are reported in the present article, while the results will be discussed in a subsequent paper.
Key words: Human skulls, mandibular dimensions, measurement devices, computer data, mandibular prostheses.

Introduction

Surgical correction of the facial deformities occurring in the maxillo-facial region often necessitates the utilization of mandibular replacements. Different biotolerant materials, e.g. metals, Al_2O_3 ceramics, etc., play a more and more important part in the rehabilitation of mandibular deficiencies and deformities due to tumor or trauma. For the planning and preoperative preparation of mandibular prostheses made from bioinert materials, it is of great advantage to determine the mandibular dimensions of a large sample of skulls of different age and sex from an anthropologically processed collection.

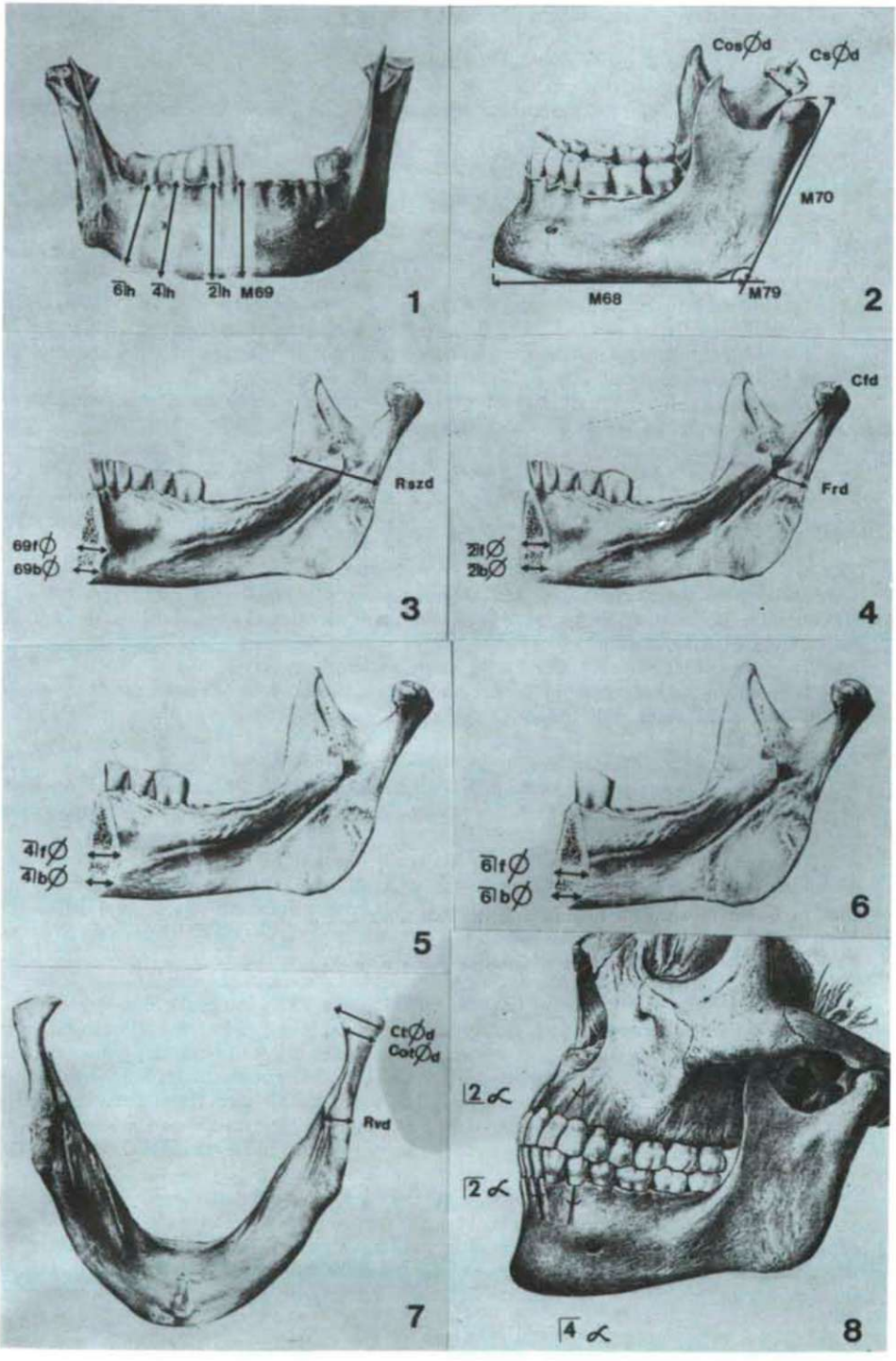
Following the measurement and computer data processing of the precisely determined dimensions, it is possible to prescribe, with the help of statistical methods, a series of mandibular condyle and corpus prostheses.

Materials and methods

528 well-preserved, European, 8th—16th-century A. D. skulls with intact mandible were evaluated from the anthropologically processed collection of the Department of Anthropology, A. J. University, Szeged. Careful sample selection was made to facilitate the creation of an informative computer data base suitable for medical biometric processing (FARKAS, 1968; JUVANCZ, 1970; BÉKY, 1971).

For classification of the dimensions of the mandibles, the following measurements were considered important for the planning of mandibular prostheses:

1. The infradentale (id) gnathion (gn) height (Martin no. 69) (M69, Fig. 1).
2. The height of the corpus mandibulae from the lower edge of the mandibular base to the alveolar margin, on the left and right sides, measured in the axis of 12, perpendicularly to the base ($\lceil\overline{2}$h and $\overline{2}\rceil$h; see $\overline{2}\rceil$h in Fig. 1).
3. The height of the corpus mandibulae from the lower edge of the mandibular base to the alveolar margin, on the left and right sides, measured in the axis of P1, perpendicularly to the base ($\lceil\overline{4}$h and $\overline{4}\rceil$h; see $\overline{4}\rceil$h in Fig. 1).
4. The distance of the lower edge of the mandibular base from the alveolar margin in the axis of the left and right M1, perpendicularly to the base ($\lceil\overline{6}$h and $\overline{6}\rceil$h; see $\overline{6}\rceil$h in Fig. 1).
5. The angle of inclination of the frontal surface of the alveolar process of the mandible to the straight line perpendicular to the Frankfurt horizontal plane measured with a goniometer following reconstruction of the occlusal relation, fixation of the mandible to the skull and setting of the Frankfurt horizontal plane; from the alveolar edge to the apical part of the root, on the left and right sides, in the axis of 12 ($\lceil\overline{2}\alpha$ and $\overline{2}\rceil\alpha$; see $\lceil\overline{2}\alpha$ in Fig. 8).
6. The angle of inclination of the frontal surface of the alveolar process of the mandible to the straight line perpendicular to the Frankfurt horizontal plane, measured from the alveolar edge to the apical part of the root, on the left and right sides, in the axis of P1 ($\lceil\overline{4}\alpha$ and $\overline{4}\rceil\alpha$; see $\lceil\overline{4}\alpha$ in Fig. 8).
7. The distance of the protruding edge of the chin from the straight lines laid on the posterior margins of the two gonions (Martin no. 68) (M68, Fig. 2).
8. The mandibular angle (Martin no. 79) (M79, Fig. 2).
9. The ramus height: rectilinear distance of the gonion (go) from the highest point of the capitulum mandibulae (Martin no. 70) (M70, Fig. 2).
10. The alveolar bend of the mandibular ridge, marked in the middle of the lower jaw ridge between the two most medial points of the foramen mentale on both sides, projected at right angles to the alveolar ridge (ml, Fig. 17).
11. The alveolar bend of the mandibular ridge, marked in the middle of the lower jaw ridge, between the center line and the two most medial points of the foramen mentale on both sides, projected at right angles to the alveolar ridge (mls and mld, Fig. 17).
12. The radii of the circles best fitting the alveolar bend of the mandibular ridge, on the left and right sides, measured between the midline and the two most medial points of the foramina mentale projected at right angles to the alveolar ridge (mrs and mrd, Fig. 18).
13. The greatest width of the corpus mandibulae at the height of the foramina mentale, measured in the axis of the symphysis mandibulae (69fØ, Fig. 3).
14. The greatest width of the corpus mandibulae at the height of the foramen mentale, measured in the axis of the left and right 12 ($\lceil\overline{2}$fØ and $\overline{2}\rceil$fØ; see $\overline{2}\rceil$fØ in Fig. 4).
15. The greatest width of the corpus mandibulae at the height of the foramen mentale, measured in the axis of the left and right P1 ($\lceil\overline{4}$fØ and $\overline{4}\rceil$fØ; see $\overline{4}\rceil$fØ in Fig. 5).
16. The greatest width of the corpus mandibulae at the height of the foramen mentale, measured in the axis of the left and right Ø1 ($\lceil\overline{6}$fØ and $\overline{6}\rceil$fØ; see $\overline{6}\rceil$fØ in Fig. 6).
17. The base width of the mandible, measured at a distance of about 3 mm from the base, in the axis of the midline between the two I1 (69bØ, Fig. 3).
18. The base width of the mandible, measured at a distance of about 3 mm from the base, in the axis of the left and right I2 ($\lceil\overline{2}$bØ and $\overline{2}\rceil$bØ; see $\overline{2}\rceil$bØ in Fig. 4).
19. The base width of the mandible, measured at a distance of about 3 mm from the base, in the axis of the left and right P1 ($\lceil\overline{4}$bØ and $\overline{4}\rceil$bØ; see $\overline{4}\rceil$bØ in Fig. 5).


6h 4h 2h M69
1
CosØd
CsØd
M70
M68
M79
2
Rszd
69fØ
69bØ
3
Cfd
Frd
2fØ
2bØ
4
4fØ
4bØ
5
6fØ
6bØ
6
CtØd
CotØd
Rvd
7
2α
2α
4α
8

20. The base width of the mandible, measured at a distance of 3 mm from the base, in the axis of the left and right Ø1 ($\overline{6}$bØ and $\overline{6}$| bØ; see $\overline{6}$| bØ in Fig. 6).

21. The base contour of the mandible (Fig. 12B).

22. The lateral contour of the mandible (Fig. 12C).

23. The greatest transversal diameter of the left and right capitulum mandibulae (CtØs and CtØd; see CtØd in Fig. 7).

24. The greatest sagittal diameter of the left and right capitulum mandibulae (CsØs and CsØd; see CsØd in Fig. 2).

25. The transversal diameter of the collum mandibulae at the height of the sagittal diameter, measured perpendicularly to it on the left and right sides (CotØs and CotØd; see CotØd in Fig. 7).

26. The smallest sagittal diameter of the collum mandibulae on the left and right sides (CosØs and CosØd; see CosØd in Fig. 2).

27. The distance between the highest point of the capitulum mandibulae and the lowest point of the foramen mandibulae on the left and right sides (Cfs and Cfd; see Cfd in Fig. 4).

28. The width of the ramus mandibulae, on the left and right sides, measured at the height of the lowest point of the foramen mandibulae (Rszs and Rszd; see Rszd in Fig. 3).

29. The transversal width of the dorsal side of the ramus mandibulae, on the left and right sides, at the height of the foramen mandibulae (Rvs and Rvd; see Rvd in Fig. 7).

30. The rectilinear distance of the foramen mandibulae from the dorsal side of the ramus mandibulae, measured at right angles on the left and right sides (Frs and Frd; see Frd in Fig. 4).

31. The length of the external arc of the mandibular base contour on the left side between the center line and the most medial point of the foramen mentale, projected at right angles to the external arc (lfks, Fig. 19).

32. The radius of the circle that best fits the above arc length (rfks, Fig. 20).

33. The length of the external arc of the mandibular base contour on the left side between the most medial point of the foramen mentale, projected at right angles to the external arc, and the extremity of the external arc (lvks, Fig. 19).

34. The radius of the circle that best fits the above arc length (rvks, Fig. 20).

35. The length of the internal arc of the mandibular base contour on the left side between the center line and the most medial point of the foramen mentale, projected at right angles to the internal arc (lfbs, Fig. 19).

36. The radius of the circle that best fits the above arc length (rfbs, Fig. 20).

37. The length of the internal arc of the mandibular base contour on the left side between the most medial point of the foramen mentale, projected at right angles to the internal arc, and the extremity of the internal arc (lvbs, Fig. 19).

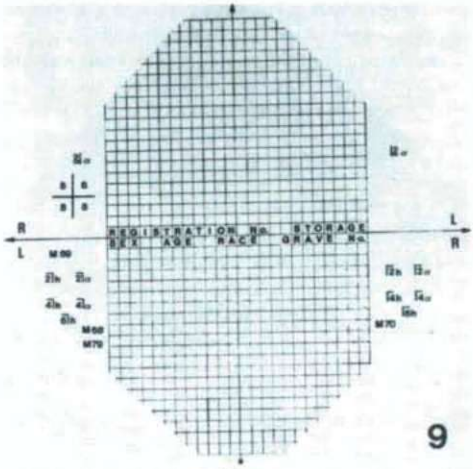
38. The radius of the circle that best fits the above arc length (rvbs, Fig. 20).

Anthropologically defined anatomical points and experience emerging from previous studies of the lower jaw were employed for the better comparison and classification of the measurements of the human mandibles (TÖRÖK, 1890, 1898, 1899; SOMOGYI, 1953; MARTIN and SALLER, 1957; BERNAU and KÖNING, 1968; MOORE et al., 1968; FAGOS et al., 1973).

The dimensions were determined with anthropometric instruments, e.g. slide gauge, calipers, goniometer, mandibulometer (MARTIN and SALLER, 1957; FARKAS, 1972), etc. in the following way:

a) Celluloid transparencies were prepared for the evaluation of the alveolar bend of the mandibular ridge and for the simultaneous recording of the acquired measurement data. Short designations of the dimensions were marked on the transparencies (Fig. 9 and 11), while the identifying data, registration number, age, sex, storage site, etc. were recorded on foil sheets attached to them (Fig. 10 and 12). Figure 13 shows the determination of the alveolar bend of the lower jaw ridge. The mandible to be measured was fixed in a mandibulometer, the transparency with a foil sheet was placed on the mandibular ridge, and the arch was simply marked with a permanent pen.

b) The length of a part of the alveolar bend was determined with a simple device. Thin steel wire was passed through a disposable hypodermic needle, the major part of which had previously been cut off, and the end of the wire was marked with a cross. The cross mark was fitted to the origin of the arch, the flexible wire was laid on the bend, and the cone of the needle was slid to the extremity (Fig. 14). The wire was then straightened out and the length of the arch was read off a scale paper.



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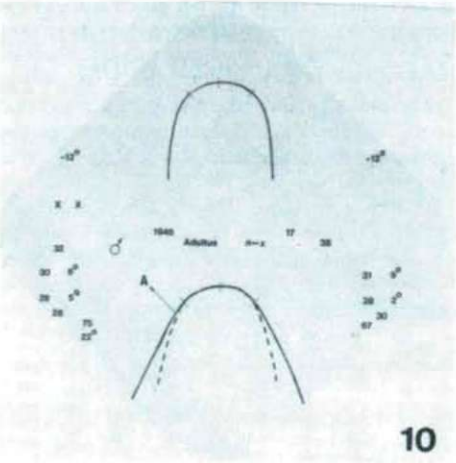

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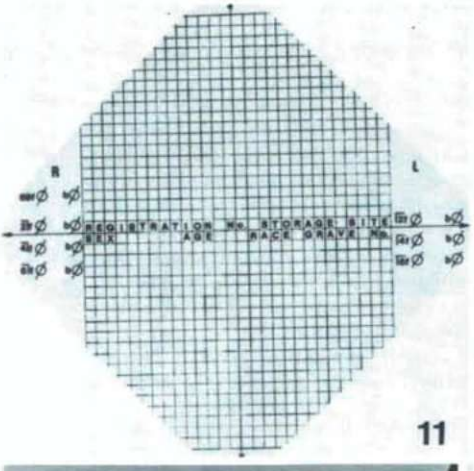

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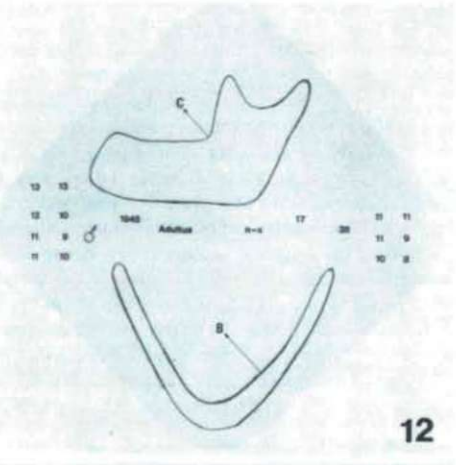

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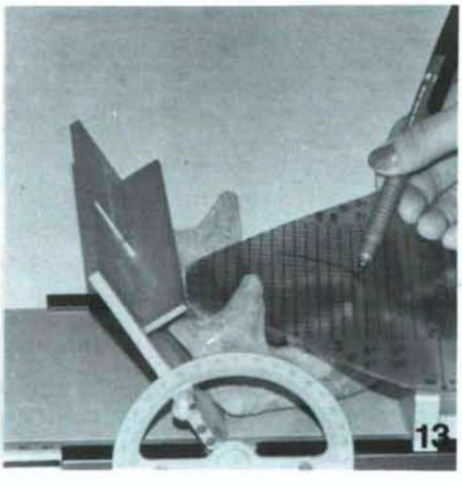

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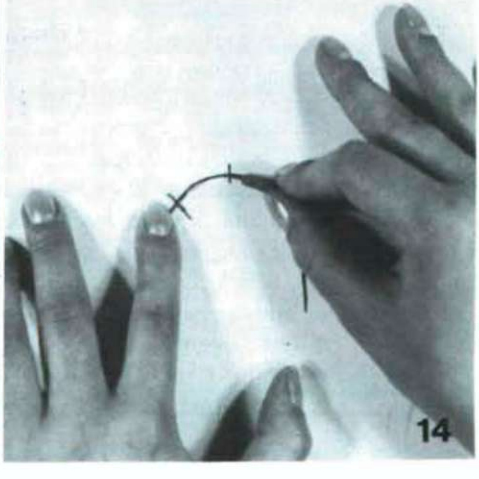

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c) The radius of the circle best fitting a part of an arch was given with two other home-made transparencies. The bisectors of the square measuring devices were marked with a mm scale. The upper edge of one of the transparencies was placed as tangent to the origin of the arch (Fig. 15), while the other was similarly laid tangentially to the extremity (Fig. 16). At the intersection of the bisectors, their lengths were read off the mm scales and averaged, and this average was taken as the radius of the circle that best fits the alveolar ridge. Special transparencies are often used in many fields of clinical practice, e.g. Orthogrids in orthodontics for obtaining rapid measurements from a cephalometric radiograph (MCEWEN and MARTIN, 1967).

Two mandibular contours were established:

d) The mandible to be examined was placed on a piece of graph paper and was pressed down at the premolar-molar region with the left hand. The base of the mandible was followed precisely, and the contour was simply drawn with a sharp pencil with the right hand. The center line and the foramina mentale were marked and the contour was also copied onto the foil record for examination (Fig. 12B).

e) A camera and a cephalostat (PONYI and NYILASI, 1971) were used for the determination of the other mandibular contour. With regard to the occlusal relations, the mandible was taped to the skull and a 10 cm piece of copper wire was fixed to the mandibular corpus. The skull was placed in the cephalostat and, from a distance of 152 cm, the measuring distance of lateral cephalograms, a lateral photograph was taken with a 135 mm teleobjective (Fig. 21). After processing of the film, the negative was put in an enlarger and the picture was enlarged with the help of the 10 cm copper wire to 1:1 size. The contour was drawn on graph paper and was copied onto the foil record for examination, too (Fig. 12C). The lateral mandibular contours achieved in this way will later be used for comparison with those of X-ray cephalograms to derive further measurement data (NITSCHE and VÁLYI, 1955; SAVARA et al., 1966).

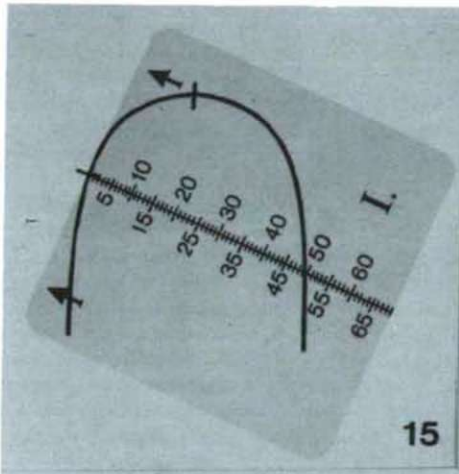
f) For the measurement of the angle of inclination of the frontal surface of the alveolar process of the mandible, a craniophore, a positioner needle and a goniometer were used. Only those skull samples were examined in which the dentition was satisfactorily intact for fixation of the mandible to the skull with regard to the accurate occlusal relation. The skull was stabilized in the craniophore, it was set in the Frankfurt horizontal plane with the positioner, and the measurements were made with the goniometer (Fig. 22). The alveolar edges of the upper and lower jaw ridges and the frontal surfaces of the alveolar processes at the height of the apical part of the dental roots, in the axes of the upper and lower I2 and the lower P1 on both sides, were established as the measuring points of the angle of inclination. The angles were measured to the straight line perpendicular to the Frankfurt horizontal plane. Angles anterior to this straight line were taken as positive, and those posterior to it as negative.

Classification of the measured dimensions and percentage frequency analysis were performed by computer. The measurement data were then displayed in charts, and the class medians and their percentage distribution representing the sample were also calculated.

Discussion

On the basis of the determined mandibular dimensions, the preparation of wax models of mandibular replacements is planned, with average sizes equal to the class medians. With the help of the created computer database, that number of mandibles required in the replacement series, with dimensions corresponding to the averages for the class medians, are to be chosen from the anthropologically processed collection of the Department of Anthropology, A. J. University, Szeged. Impressions will then be taken from the selected mandibles for the preparation of wax models. Final refinement of these, according to the calculated average dimensions, will give the actual replacement series.

The most up-to-date procedure known for the planning of mandibular replacements is three-dimensional CT imaging and subsequent computer modeling



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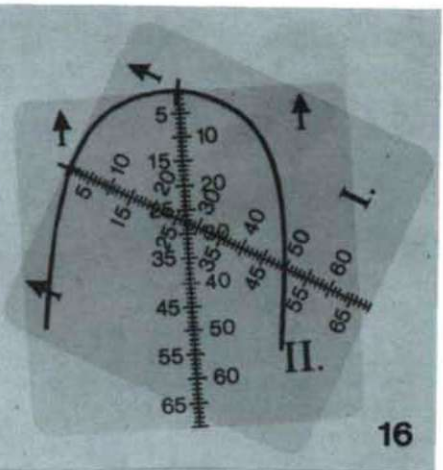

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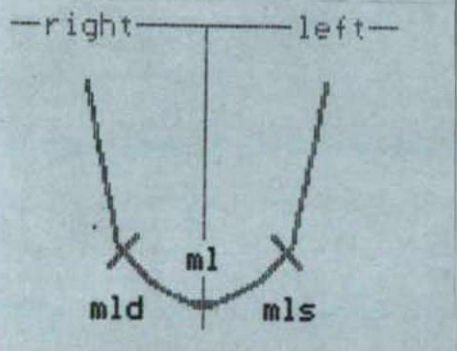

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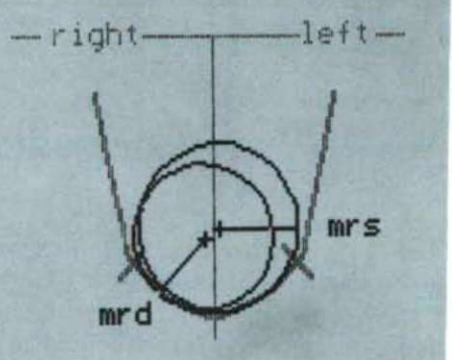

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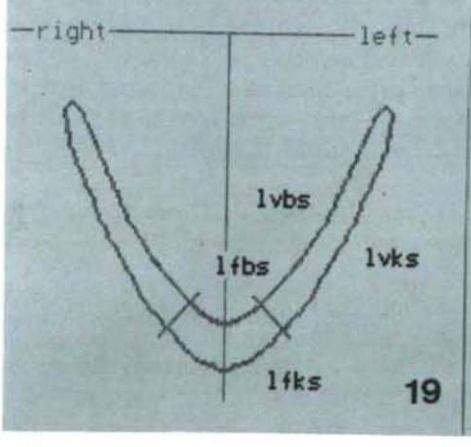

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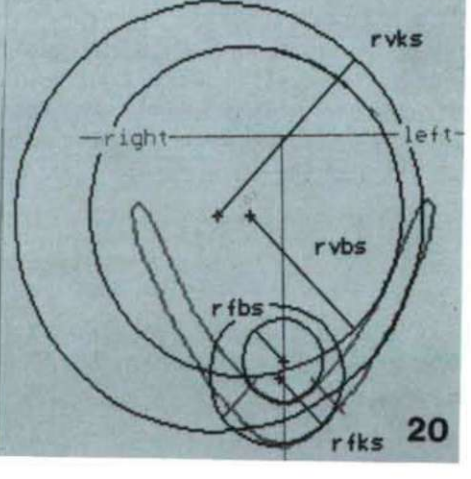

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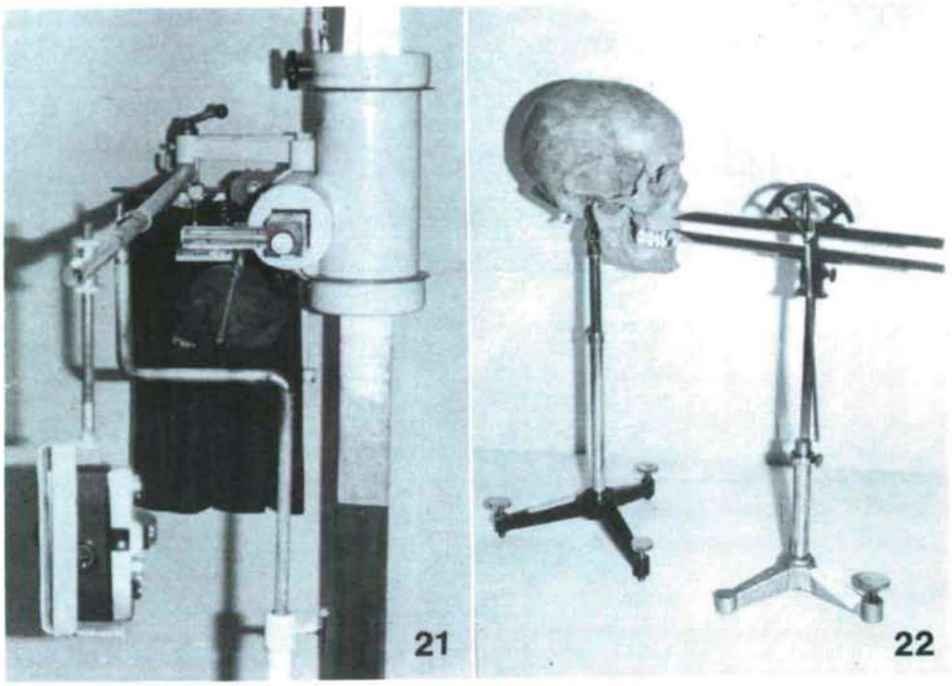

(LOBREGT and SCHAARS, 1987; TANAKA et al., 1988), which is today very costly and frequently inaccessible.

Our method, however, offers an alternative possibility for predetermination of the dimensions of factory-produced mandibular prostheses. A knowledge of the percentage distributions of the measurement data facilitates stipulation of the numbers of the various types of mandibular replacement to be produced.

The future broadening of our computer databank is planned, utilization of which is equally valuable for scientific studies of, for example, the differences between the dimensions of the left and right sides, the two sexes, the dimensions of skulls from different historical periods and different archeological sites, etc., and for practical aims. Apart from the planning of mandibular replacements, the measurement data provide information that is of great value for the planning of dental implants better fitting the anatomical conditions of the jaws.

Acknowledgements

We are grateful to Prof. GYULA FARKAS, Director of the Department of Anthropology, A. J. University, Szeged, and to his colleagues for their support and valuable advice.

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ACTA BIOL. SZEGED. 35. PP. 231—232 (1989)

SHORT COMMUNICATION

AMINO ACID PRODUCTION ACCOMPANYING GLUTATHIONE SYNTHESIS BY IMMOBILIZED SACCHAROMYCES CEREVISIAE CELLS

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(Recevied: October 31, 1988)

Abstract

The glutathione synthesis of *Saccharomyces cerevisiae* cells entrapped in polyacrylamide gel was found to be accompanied by amino acid production as a consequence of the immobilization, a partial release of the amino acid pool was also observed.
Key words: immobilized cells, glutathione production, amino acid

Introduction

Immobilized microbial cells containing the intact enzyme system of glycolysis are able to regenerate ATP for the synthesis of glutathione (MURATA et al., 1978). The entrapment of *Saccharomyces cerevisiae* cells in polyacrylamide gel caused a change in the membrane permeability (MURATA et al., 1981). Glutathione and NAD^+ were released from the cells, but ATP was retained. By the addition of NAD^+, the ATP regenerating system was completed and the ATP produced served as energy donor for the continuous production of glutathione. We have detected a significant quantity of different amino acids released together with glutathione owing to *de novo* synthesis, as well as a partial release of the amino acid pool.

Materials and methods

CULTIVATION AND IMMOBILIZATION. *S. cerevisiae* strain IFO 2044 was obtained from the Institute of Fermentation, Osaka, Japan. Cells were cultivated and entrapped in polyacrylamide gel according to MURATA et al. (1981).

ASSAY OF GLUTATHIONE AND AMINO ACID PRODUCTION. 1.2 g of gel particles containing 0.5 g of cells was incubated in 20 ml of the culture medium suggested by MURATA et al. (1981) at 30 °C for 24 hours with continuous shaking. At appropriate times, 0.5 ml of sample was removed and the concentrations of reactants and products were determined.

Glutathione and amino acids were measured by quantitative thin-layer chromatography on Kieselgel 60 F_{254} chromatoplates (Merck AG, Darmstadt, FRG) (ÁBRAHÁM et al., 1983). The spot's were detected in Telechrom OE—974 videodensitometer (Chinoin, Budapest, Hungary). Ethanol was determined by gas chromatography, using a Chrom 4 GC chromatograph (Laboratorni Pristroje Prague, Czechoslovakia) equipped with a flame ionization detector and a Porapak Q (80—100 mesh) column. Nitrogen was used as a carrier gas and methanol as an internal standard.

Results and discussion

A mixture containing the glutathione constituent amino acids (i. e. glycine, glutamic acid and cysteine) in equimolar quantities was incubated with *S. cerevisiae* cells entrapped in polyacrylamide gel. Besides glutathione and the glutathione constituent amino acids, aspartic acid, alanine, glutamine and serine were detected in the reaction mixture (Table 1).

Table 1. Release of metabolites and amino acid pool from *S. cerevisiae* cells immobilized in polyacrylamide gel

Incubation time (hr)	Ethanol (umol)	Glutathione (umol)	Asp (umol)	Ala (umol)	Gln (umol)	Ser (umol)
0	53	0	40	0	0	—
2	174	2	56	56	60	6
4	347	9	34	100	110	12
8	1346	13	34	132	136	40
24	5646	14	34	192	176	60

On this basis it was assumed that the cell membrane became permeable for glutathione and for certain amino acids as a consequence of the immobilization. Aspartic acid was released before the start of fermentation. Its concentration in the effluent remained relatively high and constant during a fairly long period. The concentrations of glutathione, alanine, glutamine and serine increased in parallel with the concentration of ethanol, showing the connection between the synthesis as energy consumer and the glycolysis as energy supplier. The synthesis of alanine, glutamine and serine presumably requires a lower ATP level than does the peptide synthesis. Aspartic acid was released from the amino acid pool of the damaged cells, but its synthesis could not be excluded.

Acknowledgements

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ACTA BIOL. SZEGED. 35. PP. 233—235 (1989)

SHORT COMMUNICATION

EFFECT OF THE HIGH TEMPERATURE ON THE MORPHOLOGICAL CHARACTERISTIC FEATURES OF THE SPOROMORPHS I

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The effect of high temperature on the sporopollenin during fossilization was first recognized by KIRCHHEIMER (1933a, b, 1935). Several results of experimental studies on this subject were published later; e. g.: SENGUPTA and ROWLEY (1974), PIÉRART (1978), ROWLEY et al. (1981). In our researches on the partial degradation of the plant cell wall high temperature as one experimental factor was also used. These experiments are in connection with the colour changes of the sporomorphs, which are useful indicators in the reconstruction of the paleoenvironment during sedimentation. Cf.: WILSON (1971), MCINTYRE (1972), GRAY and BOUCOT (1975), MANUM et al. (1977). Our investigation material was frozen at —20 °C after collection. Pollen grains of *Betula verrucosa* L., (Fig. 1—12), *Corylus avellana* L. (Fig. 13—24), *Carpinus betulus* L. (Fig. 25—32) and *Juglans nigra* L. (Fig. 33—39) were the subjects of our first experiments. From each species investigated 5 mg pollen material were measured five times. Temperature: +200 °C, lenght of time: 1, 2, 3, 4, 5, hours. The slides for light microscope investigations were prepared in glycerine-jelly hydrated of 39.6 per cent. Among the first results changes in the taxonomically important morphological characteristic features are summarized as follows:

1. The effect of +200 °C temperature may essentially change the basic morphological characteristic features of the pollen grains. This phenomenon was first observed at the triaperturate angiosperm pollen grains, as *Betula verrucosa* L. (Fig. 3—12) and *Corylus avellana* L. (Fig. 15—24). It is to be seen that the secondary morphological characteristic features are similar or identical to those of the early brevaxonate pollen grains of the European Upper Cretaceous (= *Normapolles* Group). Not so characteristic changes were observed at the pollen grains of *Carpinus betulus* L. (Fig. 27—32). Fig. 30 may be emphasized in this respect. It is interesting that no qualitative change at the pollen grains of *Juglans nigra* L. were observed (Fig. 34—39).

2. The morphological characteristics which appeared in consequence of high temperature are useful to solve phylogenetical and taxonomical problems. In this respect the pollen grains of *Betula* and *Corylus* may de derived from early brevaxonate early angiosperm of Upper Cretaceous type.

Detailed elaboration of these data is in progress, similarly further experiments on subsequent taxa.

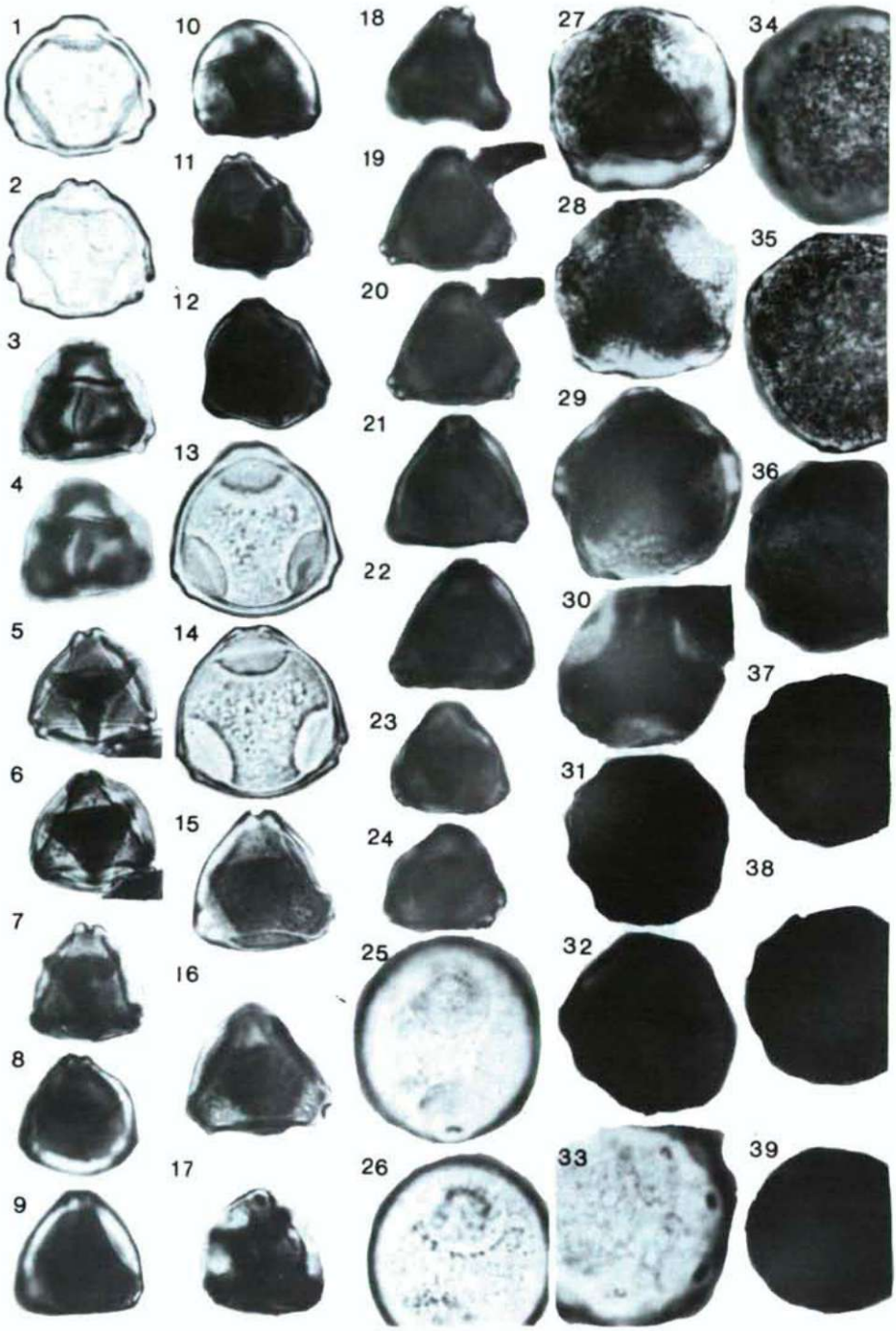
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Fig. 1—12. *Betula verrucosa* L.

1,2. Pollen grain without preparation or experiment, 3—12. Pollen grains after heating at +200 °C, 3,4. Length of time: 1 hour, 5,6. Lenght of time: 2 hours, 7,8. Lenght of time: 3 hours, 9,10. Length of time: 4 hours, 11,12. Length of time: 5 hours.

Fig. 13—24. *Corylus avellana* L.

13,14. Pollen grain without preparation or experiment, 15—24. Pollen grains after heating at +200 °C, 15,16. Length of time: 1 hour, 17,18. Length of time: 2 hours, 19,20. Length of time: 3 hours, 21,22. Length of time: 4 hours, 23,24. Length of time: 5 hours.

Fig. 25—32. *Carpinus betulus* L.

25,26. Pollen grain without preparation or experiment, 27—32. Pollen grains after heating at +200 °C, 27,28. Length of time: 1 hour, 29. Length of time: 2 hours, 30. Length of time: 3 hours, 31. Length of time: 4 hours, 32. Length of time: 5 hours.

Fig. 33—39. *Juglans nigra* L.

33. Pollen grain without preparation or experiment, 34—39. Pollen grains after heating at +200 °C, 34,35. Length of time: 1 hour, 36. Length of time: 2 hours, 37. Length of time: 3 hours, 38. Length of time: 4 hours, 39. Length of time: 5 hours.

ACTA BIOL. SZEGED. 35. PP. 237—239 (1989)

SHORT COMMUNICATION

AMINO ACIDS AS SOURCES OF NITROGEN FOR THE GROWTH OF SOME HYDROPONICALLY CULTURED PLANTS

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(Received: September 1, 1989)

Most of the amino acids are readily taken up by roots as water soluble compounds, and may act as N source, or the release of carbon skeleton can provide energy or building structures for different pathways of the metabolism.

Young seedlings of three plant species (wheat, rice and cucumber) were hydroponically cultured (facilities and methods were according to ZSOLDOS, 1984) to compare their ability to grow on nitrogen-free or single amino acid as nitrogen source containing growth solutions, and to demonstrate the effects of such feeding.

In N-free growth conditions there are some general, rapidly developing signs of N deficiency of plants. These N deficiency symptoms are the elongation of the root system and the slower growth of the shoot (MARSCHNER, 1986).

Application of four amino acids (L-Arginine, Glycine, L-Glutamine, L-Tryptophane) in concentration of 2 mM, respectively, could partially compensate these effects, but in each case the amino acid addition alone was not enough to support the normal growth.

Table 1. shows the results. Each amino acid exerted an unique effect on the growth. With exception of L-Tryptophane, which had a hormonal effect as auxin precursor, the amino acids resulted in a shorter root system (but different morphological appearance) and a shoot-growth similar to the control, grown on complete medium. From the data listed in Table 1. turned out, that the effects of

Table 1. The effect of nitrogen supply on length of roots and shoots of 10 days old seedlings of cucumber (*Cucumis sativus* L. cv. Budai csemege) and wheat (*Triticum aestivum* L. cv. GK Szeged). Plants were cultured in N-free (—N) and in 2 mM L-Arginine (+ARG), Glycine (+GLY), L-Glutamine (+GLN), L-Tryptophane (+TRP) containing medium. The control had 4 mM KNO_3 content (S<12.4).

Plant		Length in Control %				
		—N	+ARG	+GLY	+GLN	+TRP
Cucumber	Root	165.1	30.2	59.4	34.4	9.1
	Shoot	73.5	112.6	95.8	96.3	88.9
Wheat	Root	143.8	77.8	50.1	80.6	55.6
	Shoot	96.8	100.0	90.1	88.7	91.9

amino acids were not simply determined by their chemical properties, but there were characteristic variances due to biological differences between the monocotyledonous wheat and the dicotyledonous cucumber. Only one amino acid, glycine have been chosen for further experiments.

Results of the next step of the investigations are reported in the Fig. 1. Since in some cases a slight inhibition of shoot-growth have also appeared, wide range of amino acid concentration have been tested, but in condition of normal nitrate-N supply.

Comparison of growth-curves of two monocots, rice and wheat, revealed some differences concerning the effect of glycine, which might affect the regulation of N-assimilation. The curves of root-growth are almost identical, reflect higher sensitivity of wheat, but similar way of action. In interval of 0.01—5.0 mM glycine concentration the curves of shoot-growth show an opposite picture. In case of rice these amounts of glycine promoted the shoot-growth, but shoot-length of wheat decreased from the concentration of glycine higher than 0.01 mM. Effect of glycine in concentration higher than 5.0 mM seems toxic.

These opposite results on rice and wheat fit into the earlier experiences (MINOTTI, 1969; SHEN, 1969, 1976) showing differences between regulation of N-assimilation of these two species, and give indirect evidence of glycine action. Effect of glycine on uptake of ^{15}N labelled N sources (NO_3^-, NH_4^+) and $K^+(^{86}Rb)$, $H_2{}^{32}PO_4^-$ have been tested, the promising results are being evaluated.

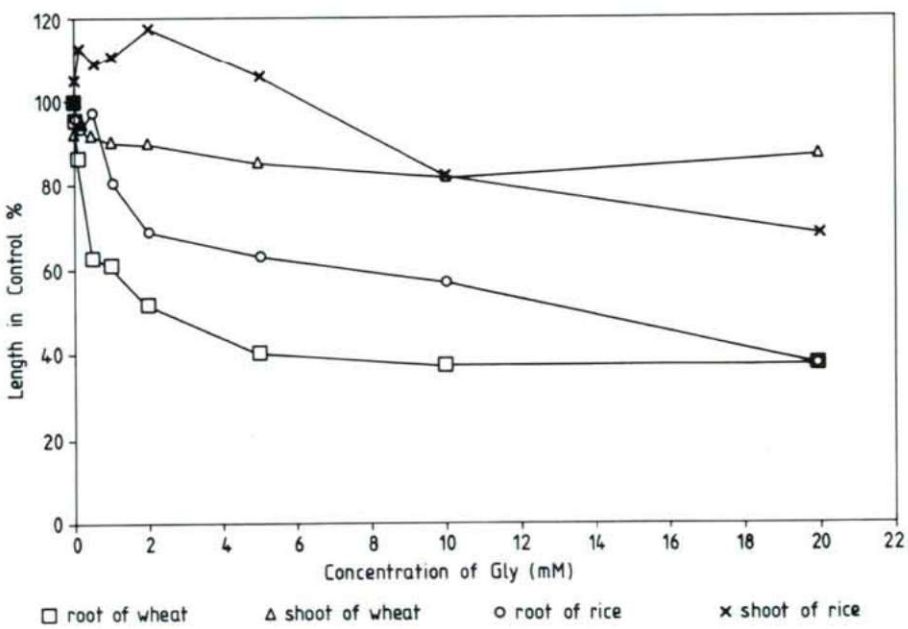

Fig. 1. The effect of glycine content (added to 4 mM KNO_3 containing medium) on length of roots and shoots of 10 days old seedlings of wheat (*Triticum aestivum* L. cv. GK Szeged) and rice (*Oryza sativa* L. cv. Oryzella). Points are 0.00, 0.01, 0.1, 0.5, 1.0, 2.0, 5.0, 10.0, 20.0 mM glycine ($S<9.6$).

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ACTA BIOL. SZEGED. 35. PP. 241—243 (1989)

THESIS OF DISSERTATION FOR CANDIDATE DEGREE

ORGANIZATION OF THE PHOTOSYNTHETIC APPARATUS IN MODIFIED CHLOROPLAST MEMBRANES

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The photosynthetic light-energy utilization is a vital autotrophic process which determines the overall productivity of the biosphere. This complicated reaction sequence takes place in the chloroplasts of plants, which possess an organized internal membrane system, containing the essential pigment-protein complexes and the components of the electron transport chain. The proper organization of the individual components as well as their assembly into structurally intact and functionally competent units is controlled by exogenous and endogenous factors. Studying the relationship between the structure and composition of photosynthetic membranes and their functional properties can significantly improve our present-day understanding about the details of the photosynthetic processes and can also contribute to the understanding of structure-function relationship in membranes in a more general sense.

Photosynthetic membranes possess some unique features as compared to other membrane systems of animal and plant origin. As concerns their lipid composition, the high proportion of galactolipids is of note, which frequently contain poly-unsaturated fatty acids (e. g. linoleic and linolenic acids). This specific lipid pattern and fatty-acid composition are the main determinants of the high fluidity level of chloroplast membranes. Membrane fluidity, or more precisely the dynamic properties of membranes have been shown to be inherently involved in important cellular processes, but in this respect little is known about the functional significance of the specific fatty acid pattern of chloroplast membranes.

Chloroplast membranes are known to contain different pigments other than chlorophylls, e. g. carotenes and xanthophylls. Their primary role in photosynthesis was assumed to be accessory pigments, which also have effective protective action against photodecomposition of photosynthetic membranes. Recently, however, it is becoming evident that these pigments also play an important role in the assembly and proper organization of pigment-protein complexes, the details of which have not been clucidated so far.

A possible way of studying these and similar problems is to bring about modifications in the usual stoichiometry of the respective components of the membrane and to study the functional consequences of the modifications. The use of specific chemical agents for this reason seemed to us a reasonable approach.

The experimental work presented in this dissertation aimed at studying

1. the structural and functional aspects of the photosynthetic apparatus in chloroplast membranes where

a) the fatty acid composition had been modified;

b) the carotenoid pigment composition had been modified.

2. the interrelationship between linolenic acid content of chloroplast membrane lipids and the photosynthetic activity of chloroplasts and leaves.

3. the direct action on photosynthesis of the chemicals that were used for causing compositional changes.

EXPERIMENTAL DETAILS

The experiments were carried out with barley (*Hordeum vulgare* L., cv. Horpácsi kétsoros) grown for 6 days under controlled laboratory conditions. The chemicals used for modifying the composition of chloroplast membranes were: *cerulenin*, an antibiotic which is an inhibitor of the do novo fatty acid biosynthesis; and two pyridazinone compounds: *SAN 6706* and *SAN 9785*, the former being a specific inhibitor of carotene biosynthesis, whereas the latter inhibits the formation of linolenic acid. The action of chemicals was studied in different experimental systems: during greening of etiolated leaves as well as during treatment of plants from the onset of germination. The direct action of the chemicals was sudied by treating fully developed green leaves.

The fatty acids were separated and analysed by gas-liquid chromatography following thin-layer chromatographic separation of lipids. Pigment content was determined by conventional photometric methods. The fine structure of chloroplasts was studied by electron microscopy. The greening of etiolated leaves was traced by low-temperature fluorescence measurements on intact leaves. In vivo photosynthetic activity of intact leaves was studied by means of fluorescence induction and $^{14}CO_2$-fixation measurements. In vitro photosynthetic activity of isolated chloroplasts was studied by polarographic measurements of oxygen uptake or evolution in the presence of various electron donor/acceptor systems. A rough estimation for the tightness of coupling between electron flow and photophosphorylation was achieved by the use of uncouplers and phosphorylation co-factors. The qualitative pattern of chlorophyll-protein complexes was studied by gel-electrophoretic separation of the polypeptides after SDS-solubilization of chloroplast membranes.

NEW EXPERIMENTAL RESULTS

— when chloroplastic fatty acid biosynthesis is inhibited by the antibiotic cerulenin, the overall greening process is slowed down, the appearances of the two photosystems and of the electron transport activity are delayed. Nevertheless,

cerulenin treatment did not cause complete absence or inactivation of either of the photosystems;

— to the best of our knowledge, our group was the first to demonstrate that cerulenin is a potent inhibitor of de novo fatty acid biosynthesis in chloroplasts. Furthermore, a specific action of cerulenin was observed in the fatty acid compositions of MGDG and phosphatidyl choline;

— when linolenic acid biosynthesis is inhibited in the developing chloroplasts by SAN 9785, a reduction in the amount of the chlorophyll-protein complex(es) of photosystem-I was observed. Although both photosystems were found to be competent in vitro, the in vivo photosynthesis of the leaves was considerably reduced. It is concluded that the reduced linolenic acid content could contribute to the reduction of the photosynthesis, since;

— a strong correlation between the linolenic acid content of chloroplast membrane lipids and the photosynthetic activity of leaves and of the chloroplasts isolated from them was established. In particular, the activity of photosystem-II and the tightness of coupling showed strong correlations with the actual linolenic acid content;

— when carotene biosynthesis is inhibited in developing chloroplasts by SAN 6706, no photosystem-II activity was detected with an apparent lack of the chlorophyll-protein complex of photosystem-II. The lack of carotene pigments, however, did not lead to the disappearance of xanthophylls, which, together with the remaining chlorophylls, could exert important stabilizing role on the light-harvesting chlorophyll-protein complex;

— photosystem-I was found to be competent both in linolenic acidand carotene-deficient chloroplasts, but its chlorophyll-protein complex(es) exhibited different spectroscopic characteristics when isolated from the membrane, suggesting that the complexes developed in the treated leaves possessed reduced structural intactness;

— a strong correlation was observed between the $(F_m—F_i)/F_m$ ratio, calculated from the fast-fluorescence induction curves of leaves, and the relative area above the fluorescence induction curves. This means that the $(F_m—F_i)/F_m$ quantity can serve as a reliable indicator of the rate of electron transport between Q and the plastoquinone pool, therefore, its use in quick tests is recommended.

The experimental data obtained during the studies are mainly concerning with basic science, since our primary interest was to study the organization of photosynthetic membranes and to seek for interrelations between structure and function in chloroplast membranes. We hope, however, that the demonstrated actions of the respective chemicals could initiate further studies for their potential applicability in terms of plant protective strategies.

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CHRONICLE
1989

Appointment

PROF. DR. FERENC ZSOLDOS has been appointed to the head of the Group of Biological Departments by the Rector of the A. J. University.

ASS. PROF. DR. LÁSZLÓ GALLÉ has been appointed to the secretary of the Group of Biological Departments by the Rector of A. J. University.

ASS. PROF. DR. LAJOS ERDÉLYI has been appointed to the head of the Comparative Physiology by the Rector of A. J. University.

DR. PÉTER MARÓY has been appointed to an Ass. Prof. and the head of the Department of Genetics by the Rector of A. J. University.

DR. IMRE MÉCS has been appointed to an Ass. Prof. and the head of the Department of Biotechnology by the Rector of A. J. University.

The Minister of Cultural Affairs has appointed DR. ATTILA BARANYI, DR. MAGDOLNA SZENTE, DR. JÓZSEF TOLDI (Department of Comparative Physiology), DR. JÁNOS GAUSZ (Department of Genetics) to Ass. Prof.

Retiring

Honorary PROF. DR. GÁBOR PÁLFY (Department of Plant-Physiology) and ASS. PROF. DR. GYÖRGY BODROGKÖZY (Department of Botany) retired.

New Department

The Department of Biotechnology at the A. J. University has been organized on 1st July 1989.

Scientific degree

The candidate's degree in biological sciences has been gained by DR. ERZSÉBET MIHALIK (Department of Botany).

Awards

PROF. DR. LÁSZLÓ SZALAI the chair-holder of the Department of Biophysics received a Medallion of European Society of Photobiology.

Photo of Medallion

'Award for Outstanding Work' were given by the Minister of Cultural Affairs to:

ASS. PROF. DR. LAJOS ERDÉLYI, chair-holder of the Department of Comparative Physiology,

HONORARY PROF. DR. GÁBOR PÁLFY (Department of Plant-Physiology),

First Ass. DR. LÁSZLÓ DORGAI (Department of Genetics),

First Ass. DR. KATALIN HALASY (Department of Zoology),

First Ass. DR. ERZSÉBET MIHALIK (Department of Botany),

Varia

PROF. DR. LÁSZLÓ SZALAI, the chair-holder of the Department of Biophysics was the Committee member of scientific program on the III. Congress organized by the European Society for Photobiology (27 August—2 Sept).

Honorary PROF. DR. MIKLÓS KEDVES has become the regional representative of American Association of Stratigraphic Palynologists Central European Group (Austria, Czehoslovakia, Hungary, Poland, Romania, Switzerland and Yugoslavia).

Ass. Prof. DR. FERENC BICZÓK has got an Honorary Prof. title from the Senate of A. J. University.

Ass. Prof. DR. LÁSZLÓ KÖRTVÉLYESSY received a Gold diploma of fifty years' standing by the Senate of the A. J. University.

The 5th Symposium of Plant Anatomy in Hungary and Greguss's Centenary

On the occasion of the birth centenary of the world famous professor of xylotomy Dr. PÁL GREGUSS the 5th. Symposium of Plant Anatomy was organised at the Department of Botany of A. J. University on the 25th—26th of August in 1989, at Szeged.

One of his former students Ass. Prof. Dr. S. GULYÁS, the head of the Department of Botany of A. J. University delivered an address about the life and work of P. GREGUSS. He emphasized the results of the 75 years' hard work. P. GREGUSS has written 46 books, 10 lecture notes, 254 scientific articles (Bibliography of P. GREGUSS see in Acta Biol. Szeged. 31. 1985. 207—214.).

From among 70 participants of the Symposium 56 researchers coming from 10 higher education and 13 research institutes held 42 lectures about the latest results of their researches.

The abstracts of the lectures were published in Hungarian and English languages.

Beside this publication the participants were given the „GREGUSS medallion" made by ANDRÁS LAPIS sculptor.

Photo of GREGUSS medallion

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